Weather Around the World

By the same author

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HURRICANES: THEIR NATURE AND HISTORY

Weather Around the World

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PREFACE

"Why have another book about the weather?" In these days the war is taking hundreds of thousands of Americans to distant parts of the world; for the first time they are leaving North America for long trips over the sea to other continents. After the war many thousands of our citizens will continue to travel by sea and air to nearly all parts of the globe. There is no single book that answers conveniently the questions they will have in mind. Books that deal with the climates of the continents contain too many technical matters and have no space for weather at sea. Books about the sea have the same defects with reference to technical matters and the climates of the continents.

Books on meteorology are devoted largely to the technique of observation, weather maps, composition of the atmosphere, instruments, methods of predicting the weather, and other subjects, but contain nothing to indicate briefly the kind of weather we are likely to find in crossing the Atlantic Ocean in April, for example, and proceeding through Africa to the Middle East in May or June.

Of course we can go to the libraries and search for weather records, but we find too much confusion. Temperatures may be given on the centigrade scale. Rain and snow may be in millimeters. Names of weather stations are not found on the maps. For example, we can't find weather records for London or Utrecht or Shanghai. The records are published under the name of some observatory unknown to all except the professional meteorologist or climatologist.

So what do we do? If we were really in earnest about it, and were not sure where the war or business would take us, we would have to gather thirty or forty pilot charts and a small library of books about the sea, clouds, meteorology and climate, and resolve to take the time to learn about millibar, centigrade, millimeter, isobar, isotherm, anomaly, normal, and atmospheric circulation, so that we could weed out the technical matters of little interest and retain a general impression of the weather around the world and

what it means in terms of the weather we know at home in the United States.

This book is intended to serve as a general introduction to world weather for the layman, and, for some purposes, to replace that "small library" of books, charts, and tables. But there is a lot of weather in the world and we cannot put it all in a small book. So we have to answer the questions that will come to the mind of the traveler who lacks the time to become master of another science, and to present it in the form of a weather supplement to the well known guide book for the traveler.

Three-fourths of the earth's surface is water, and therefore any world-wide treatment of weather must emphasize the oceans. Two-thirds of the cities of the world with a population of more than a million are situated on or very near the sea. Until we go to the interior of the continents the weather we experience is under the direct control of the sea. The farther we go from the sea, both

FIG. 1. Steamship *Manhattan* of United States Lines entering New York harbor. (Courtesy United States Lines)

in horizontal distance and in elevation, the less hospitable the climate is likely to become until we reach the unproductive desert and the barren peaks and ridges of the highest mountains. But no matter where we go from North America, a journey over water is the way we start. If our destination is outside the Western Hemisphere, our sea trip may be a long one. Long or short a sea voyage comes first, so this book begins with the ocean.

Acknowledgment is made to the U.S. Weather Bureau as the source of most of the information contained in this book. However, credit really goes back to the original observers, many of whom kept weather records as a hobby; they made possible in all parts of the world the accumulation of data required as a background for everyone who studies or writes about the weather.

CHAPTER I

WIND AND WAVES

FROM ancient times, men have had sufficient knowledge of the winds to take advantage of seasonal changes. For centuries, merchant ships changed courses with the seasons as the winds changed. The Romans carried on a large sea trade with India, taking advantage of strong seasonal winds known as monsoons. Although men were familiar with the changes in prevailing winds, it is hard to believe that they sailed the seas from as early as the thirtieth century B.C. down to the eighteenth century A.D. before they discovered that storms move from place to place.

Benjamin Franklin suspected that some of the storms of the eastern United States move from southwest to northeast, but the fact was not clearly demonstrated until early in the nineteenth century. Before that time there was no satisfactory means of telling what the weather might be tomorrow. Since early times, of course, seamen have watched the changes in the sea and sky and tried, with some success, to anticipate bad weather and storms, but the use of a weather map to chart the movement of storms was unknown until relatively recent times. Entirely aside from trade significance, weather was about as likely to win a sea battle as the admirals. Trafalgar, Cape St. Vincent, the Battle of the Nile, and countless other instances can be cited, illustrating the part played in naval strategy and tactics by the "accident" of weather. Only nowadays we do not call it an accident. We know that weather is the logical consequence of natural causes, and the weatherman's job is to predict that consequence as accurately and as long ahead of time as possible. And though weather and especially wind has lost the overwhelming naval importance it had in the days of sailing ships, the rise of air power has emphasized anew the wartime importance of weather forecasts. Any operations officer in the Aleutians will testify to the truth of that statement.

That is one of the reasons for restrictions on weather information in wartime, and that is why the remarkable story of how weather forecasting is being used in the war cannot be told in full until peace comes. But anyone, knowing a few general principles, can be something of a forecaster on his own while enjoying an ocean voyage.

The first thing to notice is the surface of the sea.

The ocean rarely has a perfectly smooth surface. Even when the atmosphere is calm, there is nearly always some wave motion caused by winds at a distance. We can sit on deck on a quiet day and observe the ship's rail as it rises slowly above the horizon; it pauses there a second or two and then descends with the background of blue water rising above it. The ship rolls with the long, low undulations of the sea, which may be scarcely perceptible to the eye; sometimes the low crests come at intervals as long as fifteen to twenty seconds; somewhere, a strong wind has disturbed the surface of the sea and the undulations move outward in all directions like ripples from a stone thrown into a pond; one after another, with surprising regularity they travel surely and silently across vast stretches of ocean, raising the ship a little as they pass.

Messengers of the storm, they may well be, for every storm at sea sends out waves in all directions. Since winds are directed around the storm center somewhat like a whirlwind, and the waves move outward from it, often so rapidly that they outrun the storm, we may get the first warning of the gale in the undulations of the sea. Gradually the waves become steeper and the sea rougher with whitecaps ("white horses") everywhere; the sky becomes clouded; here and there the wind begins to carry the crests of the waves away in streaks of foam; then the gale begins; the horizon undulates and is no longer a smooth circle; finally, there are towering waves on all sides and powerful winds sweep the decks, driving the rain through a welter of foam and spray torn from the wave crests. We are now in the midst of the storm. Waves created here are constantly moving on, into quieter seas, flattening into low undulations and at last arriving at some distant coast where they pile up and spill over on the shore.

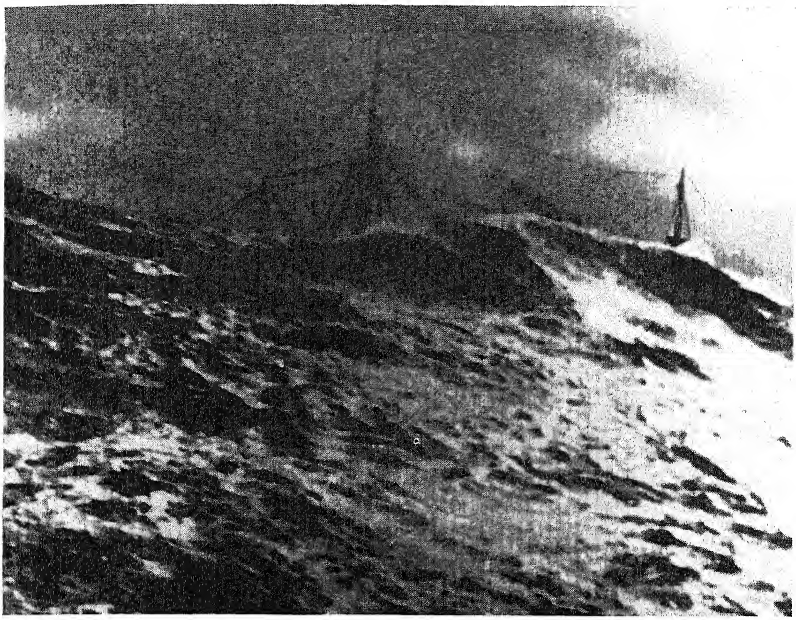


FIG. 2. Steamship *Azalea City* in a storm on the North Atlantic. (Courtesy U.S. Coast Guard)

When a strong wind blows for a long time from the same point of the compass over a long stretch of ocean, very large waves are developed; the stronger the wind and the greater the stretch of ocean over which it continues to blow, the larger the waves that are finally developed. Sometimes they become very large indeed, and they travel at great speed.

After long continuation of strong winds, great waves move with a velocity almost if not quite that of the wind itself. Waves have been observed to move at speeds estimated at more than 70 miles an hour.

We can get some idea of the size of waves by their effect on large ships. The S.S. *Olympic*, when bound from Southampton to New York on February 27, 1925, was struck during a heavy gale by a wave 70 feet high which badly damaged the navigation bridge 75 feet above sea level. The S.S. *Aquitania* bound from New York to Southampton encountered the same gale, during

which a heavy sea swept her bridge, carrying away a locker and smashing a chronometer and three sextants. The *Aquitania's* bridge was 70 feet above sea level. Seas reaching a height of 80 feet were measured by Sir Bertram Hayes on the S.S. *Majestic* in a gale of hurricane force on the Atlantic on December 29, 1922. The ship hove to and rode the waves, which were of great regularity and of phenomenal dimensions. The true wind was calculated at 75 miles an hour.

The *length* of great waves in the open sea is not so well known as their height. A strong gale on the North Atlantic may produce waves 800 feet in length from crest to crest. With long continued winds of great force, the period and speed of the waves show that their length sometimes exceeds 2,000 feet.

The most violent storms of the oceans are those which originate over the ocean near the Equator. They are more or less circular in shape with winds directed around and in toward the center. They move progressively from place to place so that the winds usually are not impressed for a long time upon the same part of the ocean. Nevertheless, the violence of the winds in tropical storms is sometimes so great that very high waves are developed in a relatively short time. Following is a traveler's description[1] of conditions in a typhoon:[2]

"At daylight I crawled out again and for some hours was privileged to behold one of the wildest and most sublime scenes that men have ever looked upon and lived to tell about. The storm was at its height. The wind was coming in gusts that reached 120 miles an hour. The air was simply filled with the white spume of the sea, just as the air is filled with snow in a great storm at home. To windward it was impossible to see more than 100 feet and to leeward not much farther. Yet through this white welter we could see something of the heights and depths that hemmed us in more than masthead high, with writhing slopes like the sides of mountains.

[1] Wright, Paul R. *The Chicago Daily News*, October 20, 1919.

[2] A typhoon is a tropical storm of the kind commonly experienced in the Pacific Ocean in the neighborhood of the Philippines and Japan.

"The wind pitched itself at us with a force that made the gale of the night before seem puny and ineffective. Altogether it was an exhibition of violence unsurpassed. The nearest approach to it is afforded by Niagara Falls, as you ride up to the foot of the tumbling waters in the *Maid of the Mist,* or walk under them to the Cave of the Winds. But here both air and water were like a Niagara let loose and driving themselves down upon our little steel ship. Against the unprotected face the hard driven spume stung like the flying particles of a sandstorm.

"It was terrible and magnificent."

Although tropical storms can be of tremendous violence, as a rule they do not produce waves as large, or at least not as long, as the winter storms of the northern oceans. Winter storms in the north are of greater diameter and consequently produce a longer continuation of strong winds over a greater sweep or "fetch" of the ocean. It is this combination of "fetch" and duration that seems to produce the greatest waves. In the South Pacific, South Atlantic and South Indian Oceans, near the 50th parallel, there is an unbroken sweep of the sea around the world, and here some very great waves are sometimes observed.

What are the biggest waves ever observed in the open sea?

This is a difficult question to answer, because in some cases no doubt the ship never came home with the story. Also, when ships have been involved in such tremendous seas, it is probable that the safety of the ship has occupied the attention of all hands with no time to calculate wave heights, even if some of the crew were curious about it.

A carefully estimated wave height of 112 feet was observed on the U.S.S. *Ramapo* in the North Pacific in February 1933.[3] For days the *Ramapo* was in a large, severe storm area, with the ship steaming in the same direction as that of the waves. Two other waves were estimated on the same occasion to be 107 and 119 feet in height. The wind was measured on an anemometer at 68 knots, or 78 land miles per hour. Although the *Ramapo* was 478 feet

[3] Whitemarsh, R. P. "Great Sea Waves." *U.S. Naval Institute Proceedings.* 60: 1094-1103. Annapolis, August 1934.

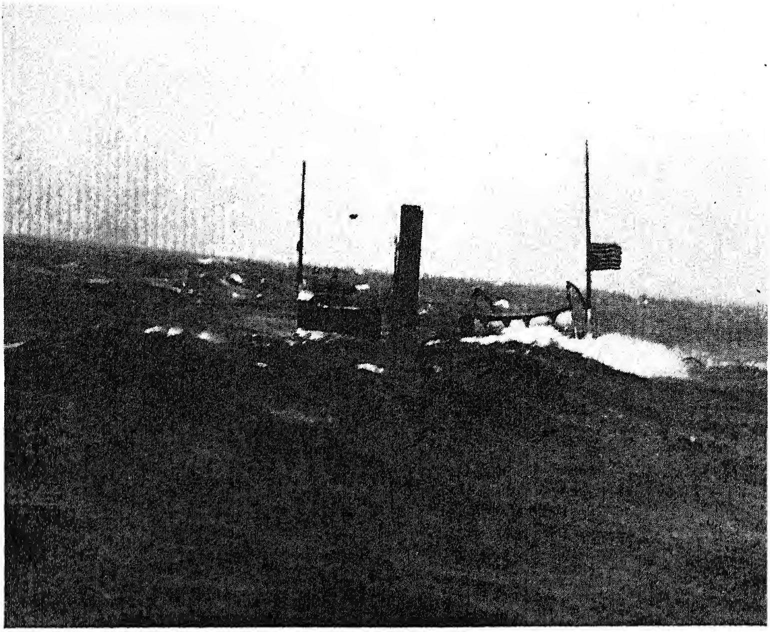


FIG. 3. Tug in trouble in a rough sea. Flag upside down is a distress signal. (Courtesy U.S. Coast Guard)

long, the ship's entire length would glide down the slope of a wave before being overtaken by the crest.

On rather rare occasions, huge solitary waves are met in the open sea when the water is otherwise calm. Some of them have swept across steamships, carrying members of the crew into the sea. It is probable that waves of this character are caused by submarine earthquakes. The greatest tidal wave of history occurred in 1883 when the top of the volcanic island of Krakatoa (near Java) blew off and sent out a wave more than 100 feet high. This historic incident is described at the end of Chapter XII.

Waves created by storm winds often move to great distances as they flatten out into long, low undulations known as groundswells or rollers. On moving into shallow water, the rollers pile up and again become great breaking waves. On the coast of

Morocco and on the islands of Ascension and St. Helena, which are south of the Equator, heavy rollers are sometimes destructive to shipping.

Rollers at Ascension have their origin in the North Atlantic; they move against the wind in southern waters and break on the northern shores of Ascension and St. Helena at intervals from November to April, which is the stormiest part of the year in the North Atlantic. The rollers arrive when there are no signs of a storm locally and hence are often entirely unexpected.

Likewise, waves originating in the southern part of the South Atlantic are known to travel long distances; sometimes they arrive on the coast at Rio de Janeiro when there is no wind; they are then called the "Windless Resaca" (surf without wind). In places the shores are protected by a granite wall ten to twelve feet high and the rollers strike the wall and occasionally leap to a height of 100 feet.

Winds at sea are named by the direction from which they come

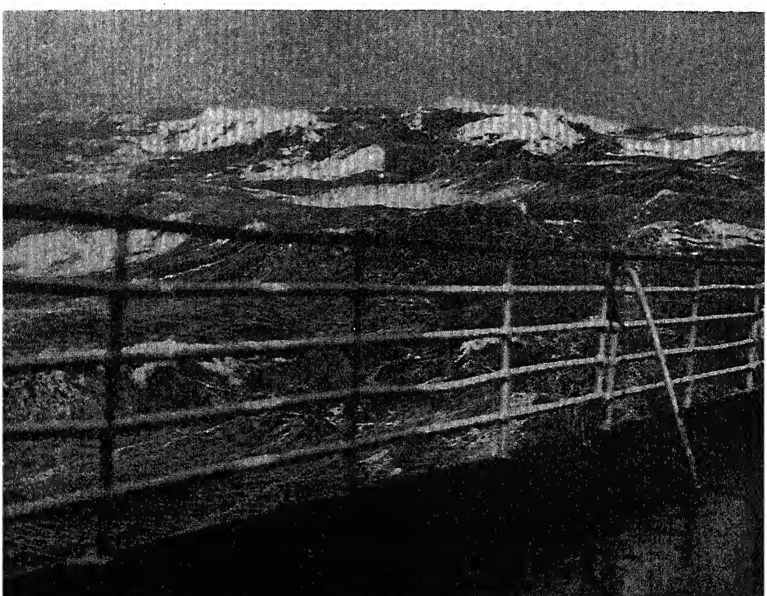


FIG. 4. Rough sea in a gale on the North Atlantic, from the promenade deck.

and by the force with which they blow. The force is described by a number on the Beaufort scale. Beaufort was an admiral of the British Navy. He devised his scale of wind force about the year 1805, and it has been universally used by mariners since that day. If a ship's officer wishes to make a record of a wind from the northeast, he may write "NE-8" which means a northeast wind with a force of 8 on the Beaufort scale.

A scale showing Beaufort wind forces and corresponding wave dimensions follows:

BEAUFORT SCALE OF WIND AND SEA[4]

	Beaufort wind force	*Wind velocity—miles an hour (statute)*	*Height of waves in feet*	*Length of waves in feet*
0	Calm	Calm	....	. .
1	Light air	1- 3	slight	ripples
2	Light breeze	4- 7	1	15
3	Gentle breeze	8-12	2	30
4	Moderate breeze	13-18	5	75
5	Fresh breeze	19-24	8	135
6	Strong breeze	25-31	12	225
7	Moderate gale	32-38	16	350
8	Fresh gale	39-46	20-25	540
9	Strong gale	47-54	25-30	800
10	Whole gale	55-63	30-40	1080
11	Storm	64-75	35-45	1400
12	Hurricane	Above 75	Over 45	Over 1800

Beaufort introduced his scale only a year or two before Robert Fulton's steamboat began plying between New York and Albany, but sails continued to propel the vast majority of ships for many years. By Beaufort's scale, the speed of the wind was judged by its effects on the sails. In the salty terms of sailing days, a wind

[4] These are only approximate measures; the size of waves depends upon the length of time the wind continues to blow with the force indicated and upon other complex conditions. Most of our information as to the height of large waves has been secured by the primitive method of finding a position in the ship where the height above the water-line is equal to the height of the waves. The observer then sees the crest of the wave top the horizon when the ship is upright in the trough of the wave.

of Force 6 (a strong breeze) was "that to which a well-conditioned ship of war (1800-1850) could just carry in chase, 'full and by,' single-reefed topsails and topgallant sails, and fishing smacks double-reef gaff mainsails."

Gradually the Beaufort descriptions of effects on sails have been abandoned. In their place, descriptions of effects on land were used, such as Force 6, when "large branches of trees are in motion, whistling is heard in telegraph wires, and umbrellas are used with difficulty," and Force 9, which causes structural damage and removes chimney pots and slate. These descriptions, of course, are no good at sea, and, having no sails, the man on the steamship has been obliged to resort to something else—the surface of the sea itself.

Some attempts have been made to use the sounds of the wind in the rigging and the noises of the sea as indicators of wind force. Wires, cables, masts—in fact all projecting parts of the ship—produce noises when the wind is high. The breaking of waves becomes a roar of the sea but it is drowned in a multitude of the voices of the wind. It is like the wind humming in the telephone wires or howling around the chimney and gables. The sounds are due to eddy motion in the air behind the obstruction to the wind. But even if we knew the relation of wind force to sounds in the rigging, it would vary in different ships.

P. Pettersen, a German sea captain, developed a scale for judging the wind force by its effects on the surface of the sea.[5] He included the noises of the sea. As examples, in his scale at Force 4 the sea gives a continual murmuring; at Force 6, the breakers march with a dull roaring noise; at Force 11 the roaring of the sea continues in an ear-splitting hubbub.

Visual scales have been proposed for international use, but it is very difficult to describe just what the ship's officer sees from the bridge when he looks out over a windswept sea. For the landlubber who has a hankering to judge for himself, the following descriptions will be useful.

[5] Pettersen, P. "Zur Bestimmung der Windstarke auf See." *Annalen der Hydrographie und Maritimen Meteorologie.* Heft III. Berlin, 1927.

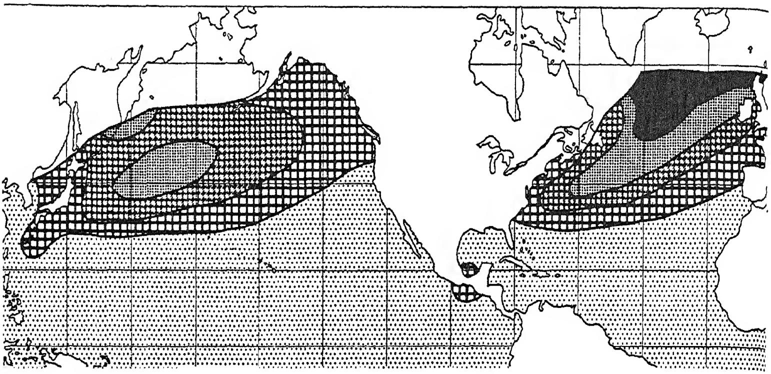


FIG. 5. Storminess on the northern oceans in December, January and February. In black area, gales (Beaufort Force 8 or higher) prevail more than 20 per cent of the time; dark stipple, 15 to 20 per cent; small hatching, 10 to 15 per cent; large hatching, 5 to 10 per cent; light stipple, less than 5 per cent; areas in white, data not shown.

When the air is calm (Force 0) the sea is glassy except where a low undulating wave or swell arrives from a distance. With a wind of Force 1 the sea is rippled in patches. At Force 2 the sea is rippled all over with miniature waves forming. At Force 3 whitecaps begin to form here and there. The ocean is generally spotted with whitecaps at Force 4. White wave crests are seen everywhere at Force 5.

When the wind increases to Force 6, large waves begin to form and the white crests of the waves here and there begin to be blown away in horizontal streaks in the gusts of wind. At Force 7 the sea heaps up and white foam is whipped by the wind and blown from the crests in lines that reveal the direction of the gusts of wind. At Force 8 the sea is very rough and foam is blown in dense streaks along the direction of the wind.

At Force 9 the sea begins to roll and on all sides dense streaks of foam are seen. At Force 10 high waves develop with long, overhanging crests and the sea is white with foam. The ship feels the shock of the waves and care must be taken to avoid injury in moving about the ship. At Force 11 small and medium-sized ships within sight are lost to view in the wave troughs and the air is filled with spray. The high breaking rollers seethe with foam. Even large ships now feel the shock of the waves. It is dangerous

to go on deck. Minor damage to boats, ventilators, etc., is likely, if the wind continues at Force 11.

When the wind increases to Force 12 it is said to be of hurricane force. Above that there are no further graduations. The sea becomes indescribable. The waves seem mountainous; their crests are carried away by the wind; large ships pitch violently; the air is so full of foam and spray that visibility is greatly reduced; if the wind continues to increase, the ship's superstructure begins to suffer serious damage.

The following are excerpts from the logs of ship captains in hurricanes: "The sea appeared to be knocked down greatly and all in a sheet of foam. I endeavored to look to windward, but I could not see; the howling of the wind was terrible." "During all this time, the passengers, although all fully aware of our situation, never opened their lips, but behaved with as much coolness as sailors. Between three and four o'clock in the morning the wind shifted to northwest and what with rain, wind, thunder and lightning, I could not make a person hear me at the top of my voice with my mouth close to his ear." "The roaring of the wind prevented us distinguishing whether it thundered or not."

With these descriptions in mind, we can form some sort of mental picture of what is going on when the ship's officer writes "NE-8" in the ship's log. But we must keep in mind that the wind

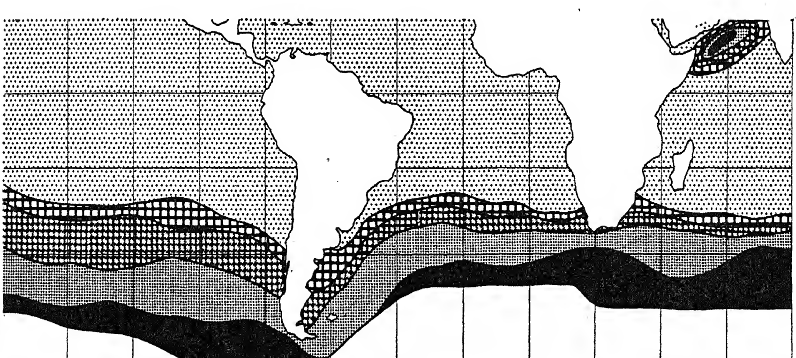


FIG. 6. Storminess in the southern oceans in June, July and August. In black areas, gales (Beaufort Force 8 or higher) prevail more than 20 per cent of the time; dark stipple, 15 to 20 per cent; small hatching, 10 to 15 per cent; large hatching, 5 to 10 per cent; light stipple, less than 5 per cent; areas in white, data not shown.

we feel on deck is seldom the true wind over the surrounding ocean. The movement of the ship must be taken into account. On fast ships of the present day, this is especially important. If the wind is blowing at a speed of 20 knots[6] *from* the east and the ship is moving at 20 knots *toward* the east, a freely exposed deck will have a wind of 40 knots. If, however, the ship were moving in the same direction as the wind, there would naturally be a virtual calm on deck. Similarly, when the wind direction is at an angle to the ship's course, we do not feel the true wind. Those who remember some of their high school physics will realize that the wind perceived on deck can be determined by a simple "parallelogram of forces," with the true wind and the forward motion of the ship representing the sides of the parallelogram. But if we have forgotten that school exercise common sense will take us to the same point anyway.

To get the true wind direction we look at the surface of the sea. Whenever the wind is blowing perceptibly there is always a pattern of lines on the surface of the sea showing the true direction of the wind. With a light wind the crests of the ripples lie in lines perpendicular to the direction of the wind. Variations in the force of the wind cause darker and lighter patches which travel along with the wind. Even with strong winds there is a pattern of lines that shows to the experienced eye the way of the wind.

We emphasize this simple matter of true wind vs. observed wind on deck because it is so essential to the amateur or professional weather man in observing the phenomena of weather at sea. With an understanding of true wind, the nature of waves, and the Beaufort scale, we have begun an understanding of storms, and may even be so perverse (from the point of view of the ship's captain or indisposed fellow passengers) as to welcome the approach of storm phenomena.

Storms are infrequently experienced on most of the ordinary

[6] At sea the rate of ship's travel is given in knots, or nautical miles *per hour*. (Note that "per hour"; only a landlubber will be so repetitious as to talk about "knots per hour.") The nautical mile is about one-seventh longer than the "land" or statute mile.

routes of ocean travel. Charts (Figs. 5 and 6) show the frequency of winds of Force 8 and higher in the northern and southern oceans in winter, which is December to February in the northern hemisphere and June to August in the southern.

Only on the northern routes of the North Pacific and North Atlantic Oceans in late autumn, winter and early spring, and near, and to the south of, the parallel of 40° in south latitude is there much likelihood of winds exceeding Force 7.

Storms which affect ships at sea, aside from purely local winds, are of two kinds, tropical and extratropical. The former originate near the Equator and travel first in a westerly direction, moving more or less away from the Equator, but they often change course on passing from the tropics and then move more directly away from the Equator and toward the east. This applies generally in both hemispheres, as is shown in Figure 7. Tropical storms include the hurricanes of the West Indies, the typhoons of the China Sea and the cyclones of the Bay of Bengal. When fully developed, they are dangerous storms. Extratropical storms, as the name implies, are those of higher latitudes but many of them are mild wind systems; only an occasional winter storm of this type is of sufficient force to be of serious danger to shipping.

Once in a long time a storm in higher latitudes is of such violence as to earn a place in history. One or two really great storms are recorded in the British Isles in a century. For example, it was reported that the "outrageous wind" of 1095 "bore down in the City of London alone 600 houses" and blew the roof off Bow Church so high into the air that its timbers in their fall "were driven 23 feet into the ground; the streets of the city being then unpaved."[7] Perhaps the most violent storm of the British Isles was the "Great Storm" of 1703, sometimes called "Defoe's Storm" because the author of *Robinson Crusoe* wrote a book about it. This great gale wrecked hundreds of houses, downed thousands of trees in the British Isles, killed 123 people on land, and many

[7] Laughton, C. and Heddon, V. *Great Storms.* Philip Allan & Co., Ltd. London, 1927.

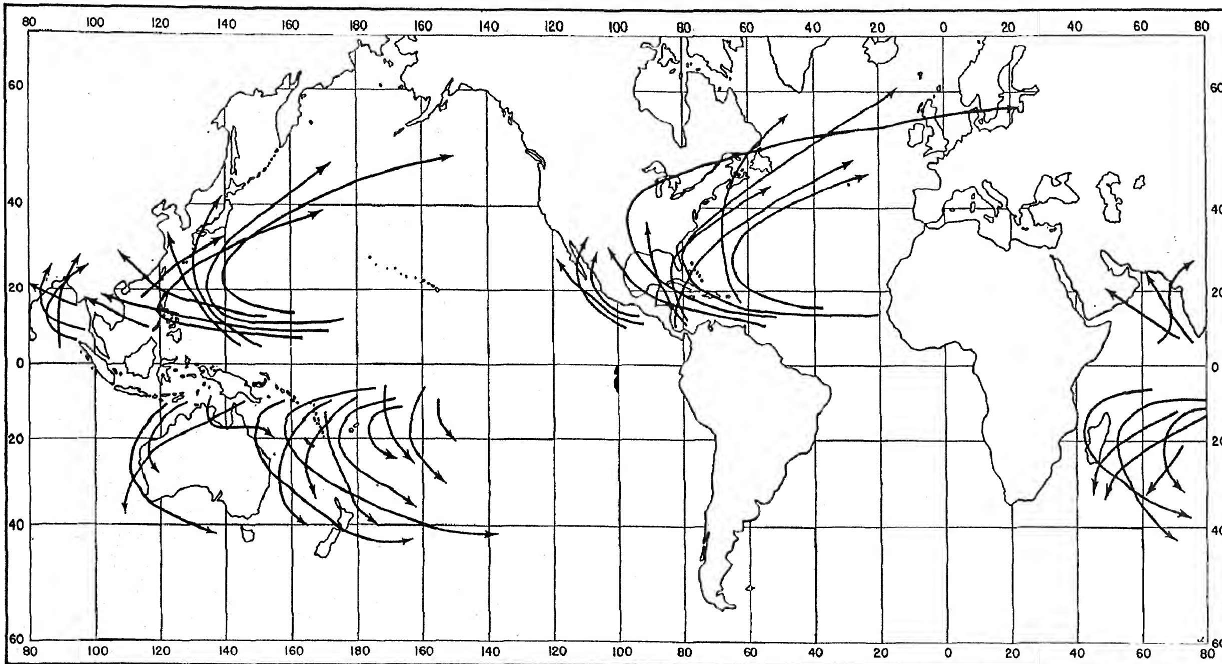


Fig. 7. Typical tracks of tropical storms in various parts of the world. Each line shows the movement of the storm center, in the direction shown by the arrow, the storm originating at the end of the line nearest the Equator. The width of the line does not indicate the size of the storm; the average diameter is 200 to 300 miles.

more were injured. More than 8,000 seamen, including 1,500 of the Royal Navy, perished.

Tropical cyclones not uncommonly move to high latitudes and a few have been very destructive there. The New England hurricane of 1938 probably caused greater economic losses than any other single storm of history, but the hurricane of August 1873 was destructive in higher latitudes, devastating parts of Nova Scotia, Labrador, and Newfoundland. More than 1,200 vessels were wrecked.

There have been a great many other furious storms on the North Atlantic Ocean. However, unless they move ashore and cause loss of life and damage to property from wind and high water they are not likely to be remembered. Nearly one thousand West Indian hurricanes have been recorded[8] but only a few have taken any prominent place in history.

One storm is worthy of special mention, however, because it was instrumental in bringing about an international system of warnings. On November 14, 1854, the "Crimean Storm" caused the loss of many ships lying at Balaklava including stores for the allied armies at Sebastopol. The loss of these stores caused intense suffering among the troops during the following winter. One of the wrecked vessels was a French warship. This induced the astronomer LeVerrier to make a study of the storm in which he traced its course from west to east across Europe. He submitted the results to Emperor Napoleon III and urged an international system of telegraphic reports for the purpose of issuing warnings of such storms. The system was established in 1855 and served as a model for other storm-warning and weather-forecasting services.

[8] Tannehill, I. R. *Hurricanes: Their Nature and History.* Princeton University Press. Princeton, 1943.

CHAPTER II

CLOUDS

We may see lots of clouds while crossing the ocean, so why not get acquainted?

Few places are better for observing clouds than on a ship at sea. Over the open ocean and above islands and seacoasts we see a great variety of cloud forms. They take almost every conceivable shape and may be at any level from the surface of the sea, where they are called fog, to a level of twelve miles above the earth's surface where high clouds are sometimes seen in the tropics. It is not astonishing, then, that the job of naming different kinds of clouds was so great a puzzle that it remained unsolved for thousands of years. Not a great deal more than a century ago (1803) an Englishman, Luke Howard, proposed a classification which is the basis of all cloud records in the world today.

To people of Howard's time, it seemed to be almost miraculous that he had at last brought order out of chaos in the cloud world. The fact that Goethe composed a poem in Howard's honor, is evidence of the enthusiasm with which his cloud classification was received. Although the proper identification of clouds is sometimes difficult, even today—so much so that the world's leading students of clouds may disagree over some of the finer points—the classification that has been developed from Howard's system is rather simple. Even a person who has never observed clouds before, except to look for imaginary shapes in the ever-changing contours, can master the elements of the classification in a few minutes.

Howard named three principal kinds of clouds:

1. On some bright days we have noticed high clouds of a fine, thin texture that moved very little or not at all; a few of these clouds looked somewhat like feathers. Maybe we have heard these fine, thin clouds, snow-white in color, called "mare's tails." Or at

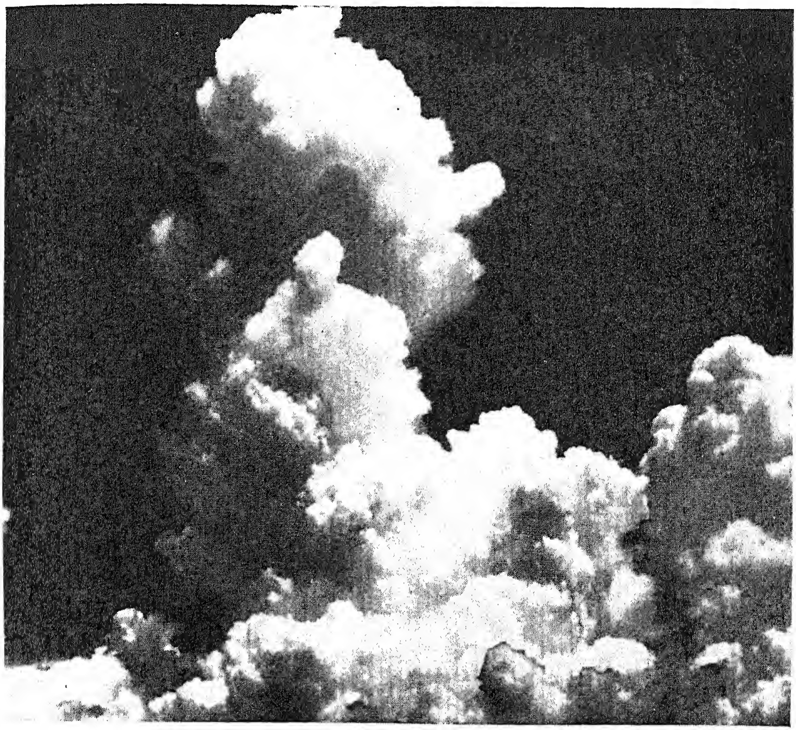


FIG. 8. Faces in the clouds (cumulus). In the upper part the curious fellow with wrinkled forehead and upturned nose takes a look at the weather. (C. E. Deppermann)

night we have noticed a large ring around the moon. Perhaps we have noticed people looking at the sun through smoked glass and on getting a dark or smoked glass have seen a similar ring in the daytime around the sun. These lunar and solar halos are caused by thin clouds.[1] Or perhaps we recall that on some occasions we have seen a sheet of high, whitish clouds, with a large patch broken up into little globules or flakes, arranged in lines or rows like the pattern on the back of a fish, and have heard this called a

[1] These halos sometimes precede bad weather, but, contrary to popular belief, the number of stars inside the halo has no significance as to how long it will be before a storm.

"mackerel sky." All of these high, thin, whitish clouds Howard named *cirrus.*

2. Then there are larger clouds, nearer the earth and of greater density. Usually, their outlines are constantly changing and we

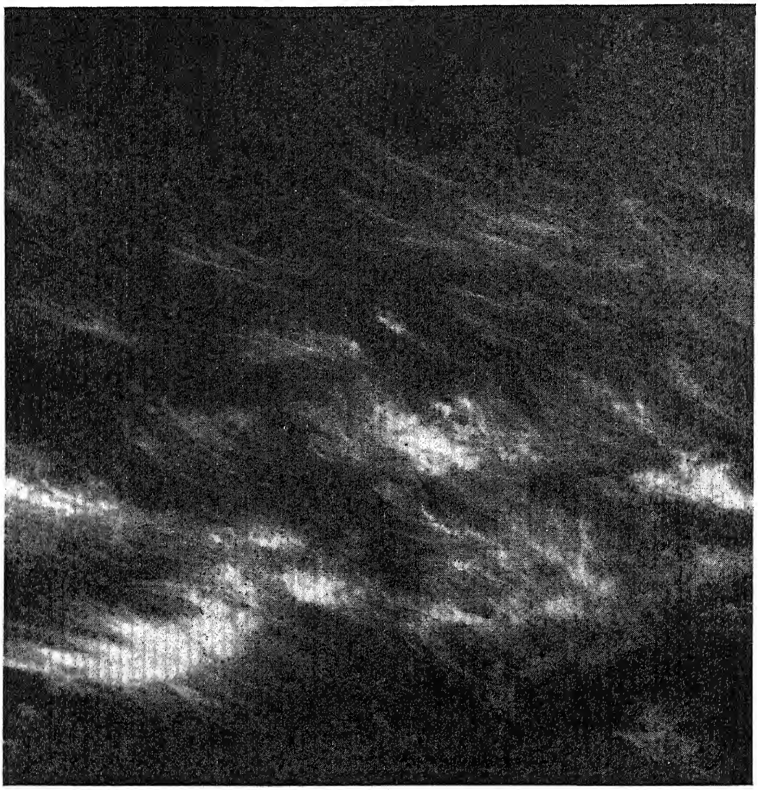


FIG. 9. Cirrus. (F. Ellerman)

may have seen edges of clouds that were shaped like faces or animals (Fig. 8). But we realize that even though the outlines were changing, there was usually something in common about all the clouds on that certain day that made them a little different

Fig. 10. Cumulus of fine weather. (C. E. Deppermann)

from the clouds on some other day. For example, we plan a picnic and on looking out we see here and there large, dense bunches of clouds with dark flat bases and grayish summits or snow-white tops in the sunlight; we see them pushing up high into the atmosphere, the kind of clouds associated in our minds with summer showers, so we close all the windows before we go out to prevent the rain from blowing into the house. This heaped-up type of cloud Howard called *cumulus*.

3. On other days, especially in winter, when it has been raining or snowing, we wonder if it is going to clear up, so we look out to see if there is an opening of blue sky in the low, grayish layer in formless masses or large rolls, moving more or less rapidly. At other times we suddenly become conscious that the sun is no longer shining. Looking out, we see that a layer of grayish clouds has spread over the sky and is growing thicker, lower and darker and then rain begins. This convinces us that we are "due for a wet spell" for somehow we have learned that the development of this kind of cloud promises more or less continuous rain for a day or two. Howard's name *stratus* has been applied to clouds of these kinds.

Even today, clouds are given these three names—*cirrus* for the high, thin clouds, *cumulus* for the heaped-up clouds, and *stratus* for the grayish layers. The three are combined with each other, or with the words *alto* (high) or *nimbus* (rain) to give us the ten different clouds now recognized, as follows:

High Clouds (average height about 4 miles)

1. Cirrus
2. Cirrocumulus
3. Cirrostratus

Middle Clouds (average height about 1 to 4 miles)

4. Altocumulus
5. Altostratus

Low Clouds (average height a few hundred feet up to about a mile)

6. Stratocumulus

7. Stratus
8. Nimbostratus

Heaped-Up Clouds (base low and flat but top may be very high)

9. Cumulus
10. Cumulonimbus

Aside from these forms, there are many special clouds such as standing clouds (cap clouds or banner clouds or crest clouds), seen near mountain tops (Figs. 36, 48). The air is in motion but the cloud continually develops into the wind and dissipates at the other end so that it appears that the air is stationary. Some of them are lens-shaped or "very like a whale"; they are called *lenticular* clouds (Figs. 18, 50, 52). Probably the most famous of all standing clouds is the "Tablecloth" that sometimes covers the flat top of Table Mountain at Capetown, South Africa (Fig. 43).

The main features of the ten principal kinds of clouds are as follows:

Clouds of Ice Crystals. The majority of clouds, especially in the lower levels, are composed of small water droplets which are less than one-thousandth of an inch in diameter. But the temperature of the atmosphere decreases with height above the surface of the earth, ordinarily at a rate of about 1° for each 300 feet of ascent; when the temperature is 70° at the surface of the open ocean, it may be as low as 20° below zero at a height of five miles.

So it is easy to understand why the high clouds, or cirrus forms, are composed of ice crystals. There are three kinds: *Cirrus* (Fig. 9) in little patches or in streaks of feathery or thread-like structure, generally white in color; *Cirrocumulus* (Fig. 12) or mackerel sky, in small rounded masses or flakes, often arranged in groups or lines like ripples in sand on the seashore or the pattern on the back of a fish; and *Cirrostratus* (Fig. 16) which is a sheet of high thin cloud that gives the sky a milky appearance, and through which the sun or moon may shine, producing a halo. The cirrus forms are usually so thin that their surfaces away from the sun have no shadows. Cirrostratus should be watched for if it grows

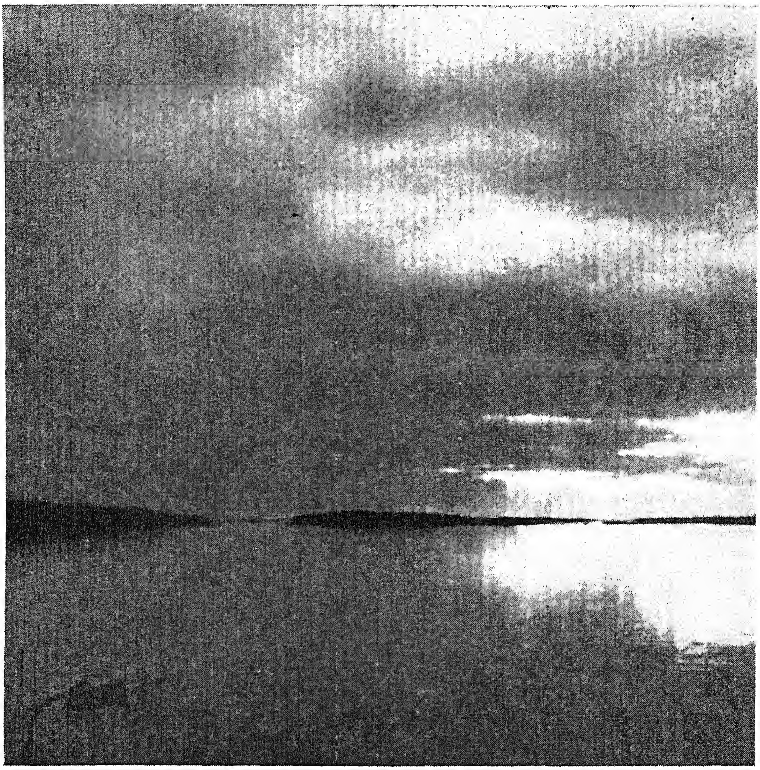


FIG. 11. Stratus. (J. Oddin)

lower and seems to thicken, it is usually a sign of the approach of a weather disturbance, probably with some rain and wind. Cirrostratus is a thin stratus cloud at a high level.

Clouds in Sheets or Layers. The other stratus clouds are *altostratus, nimbostratus*, and simply *stratus.* The highest of these is the altostratus (Fig. 45) which is a little lower than cirrostratus. It may be rather thin so that the sun or moon shines through it like ground glass, or it may grow thicker and have a dull gray color. It does not form halos around the sun or moon, for it is com-

posed of water particles or snow. When cirrostratus, growing thicker and lower, changes to altostratus, this is a more certain indication of the near approach of a weather disturbance. As the cloud sheet becomes thicker and lower and broken clouds begin to form below the sheet, with a threat of rain (or snow), the cloud usually has become nimbostratus and the disturbance is at hand with prospects of continued rain (sometimes snow) and the wind may have increased already to a fresh breeze or a moderate gale.

Stratus (Fig. 11) is a low sheet of gray cloud, almost formless,

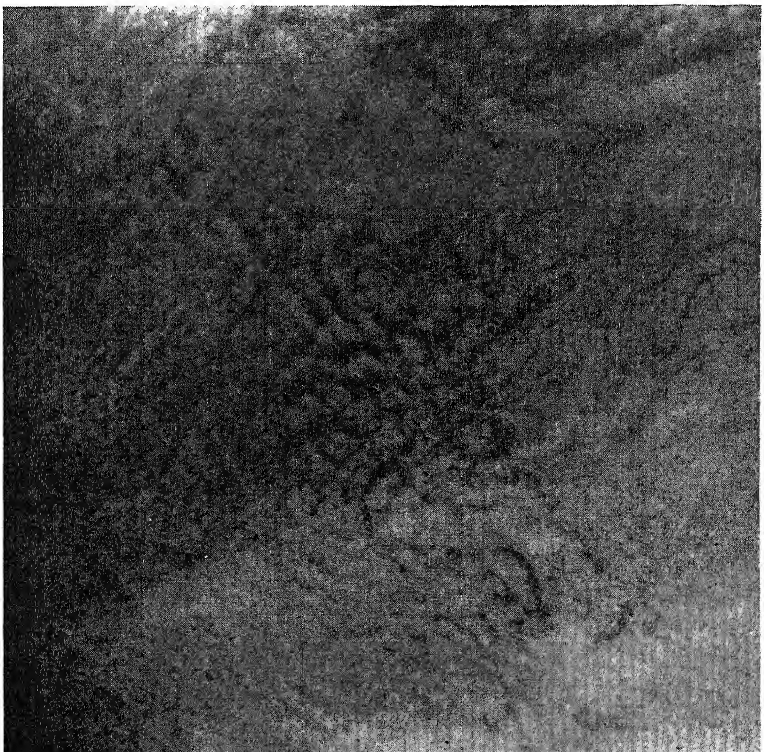


FIG. 12. Cirrocumulus. (H. T. Floreen)

FIG. 13. Altocumulus. (C. F. Brooks)

which is like high fog. Rain may come from it in the form of a fine drizzle but it does not amount to much. Stratus is not a cloud of stormy weather. It is often seen over cold waters in coastal regions and has a strong tendency to "burn off" in the morning when the sun is well above the horizon. When broken up by the wind it is called *fractostratus*.

Clouds are also commonly seen in layers or patches which are composed of more or less rounded masses or rolls. *Altocumulus* clouds (Figs. 13, 41, 53) are larger and lower than cirrocumulus;

they are usually globular masses more or less flattened and arranged in groups or lines in one or more directions. If the clouds are lower than altocumulus and are made up of larger globular or flattened masses, or the clouds appear as regular or irregular rolls of large size, with darker and lighter parts, they are called *stratocumulus* (Figs. 14, 35).

The "Heaped-up" or Cumulus Clouds. The *cumulus* cloud is a heaped-up mass, generally with a dome-shaped upper surface with rounded protuberances and a flat base. In fine weather they

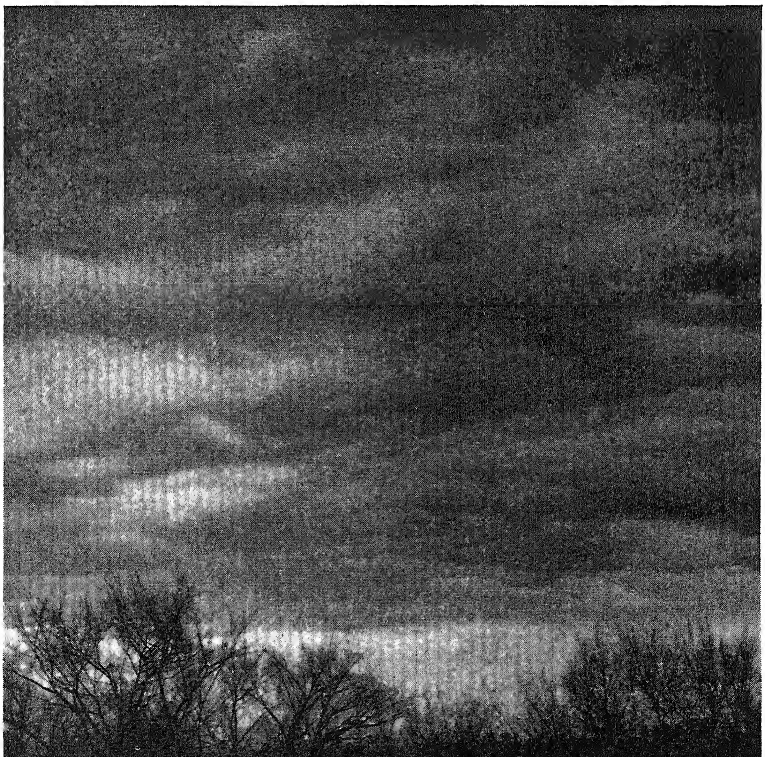


Fig. 14. Stratocumulus. (W. J. Humphreys)

appear in small masses that are bright on the sunny side and gray in the shadows; their vertical development is rather small. These are the typical clouds of the trade wind belts (Figs. 10, 15); they are often called "trade cumulus." As the day advances they may grow higher and have clear-cut surfaces shaped like a cauliflower above or they may be torn by the wind and become *fractocumulus.*

When the cumulus cloud grows to great heights (Figs. 40, 44) with parts like mountains and towers, and its top begins to lose its cauliflower appearance, spreading out at the summit in the form

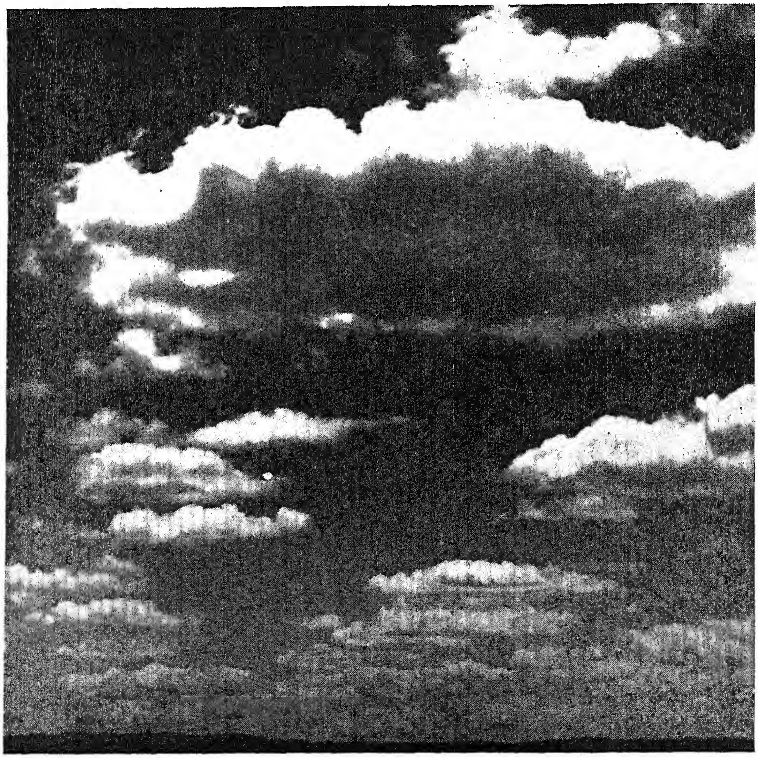


FIG. 15. Fair-weather cumulus. (C. E. Deppermann)

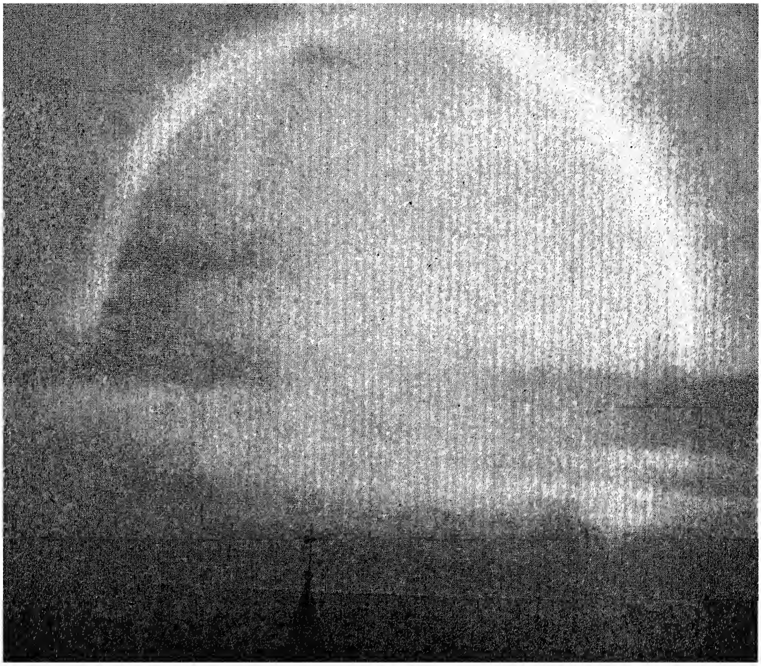


FIG. 16. Halo in cirrostratus. (G. A. Clarke)

of an anvil (Fig. 17), it has become a *cumulonimbus*. The lofty top of the cloud is now so high that it penetrates the upper layers where the temperatures are below freezing.

The cumulonimbus is the most spectacular of all. At home in the town or city we may rarely notice the development of one of these great clouds until we have heard thunder and the rain and wind squall are upon us. On the ship at sea or in port we may lazily watch the full cycle of growth of the cumulonimbus as it rises high in the atmosphere, with its cauliflower-shaped surfaces bright in the sunlight or dark in the shadows, or rimmed in silver with the sun in the background; we may see its massive towers, rising as from an explosion, its vast anvil top spreading horizontally, the lightning, the dark storm collar, and the curtain of

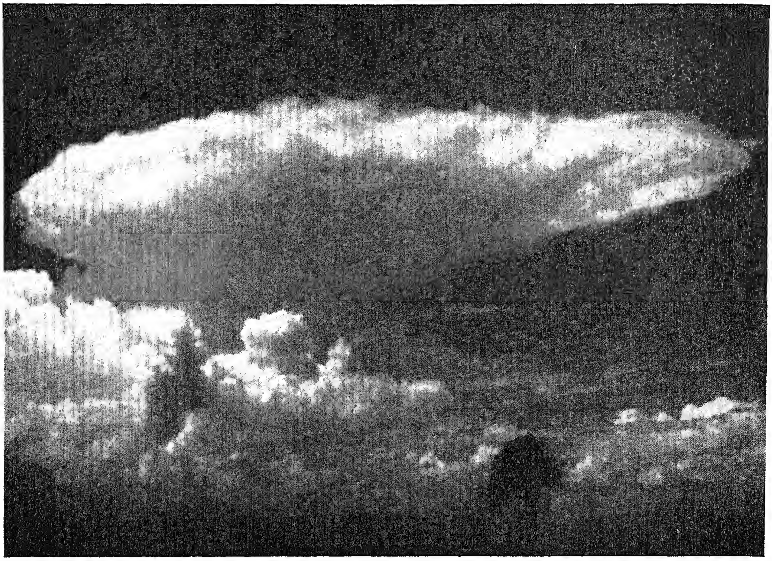


Fig. 17. Cumulonimbus. (C. E. Deppermann)

Fig. 18. Lenticular cloud. (M. Parshall)

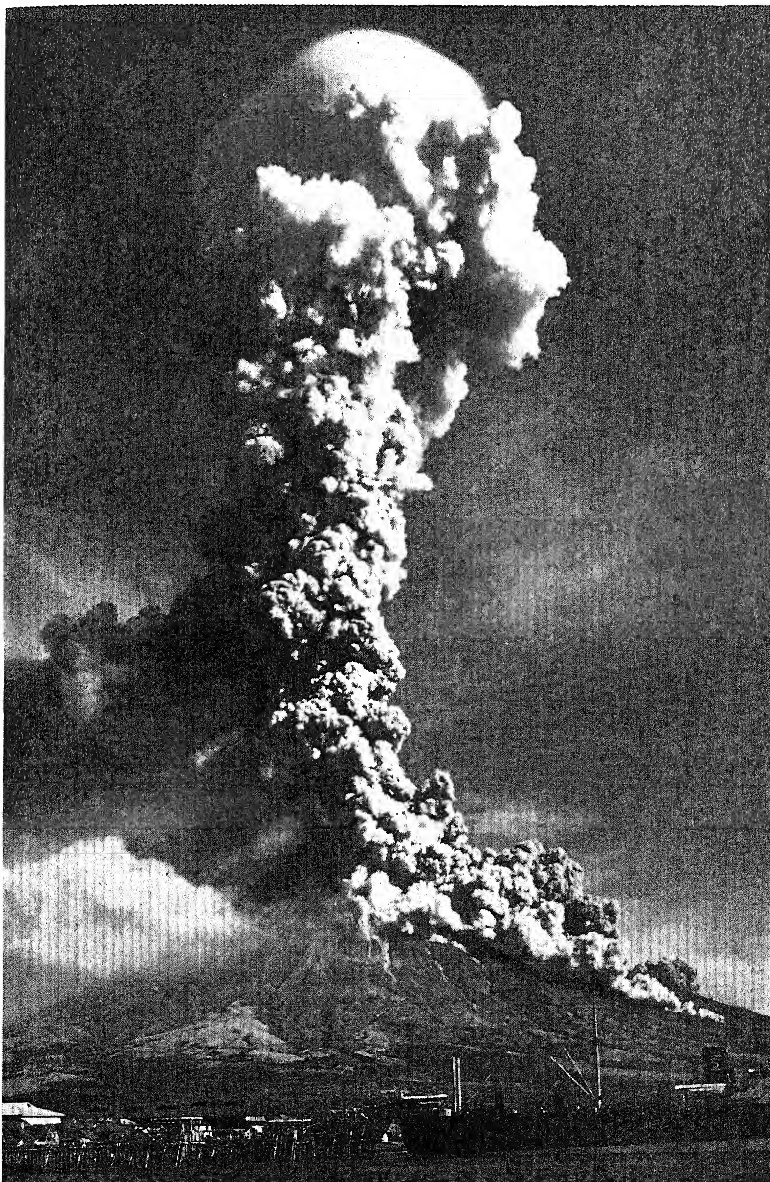


FIG. 19. Scarf cloud over Mayon Volcano during eruption, June 8, 1938. (Copyright 1938, Hollywood Studio, Legaspi)

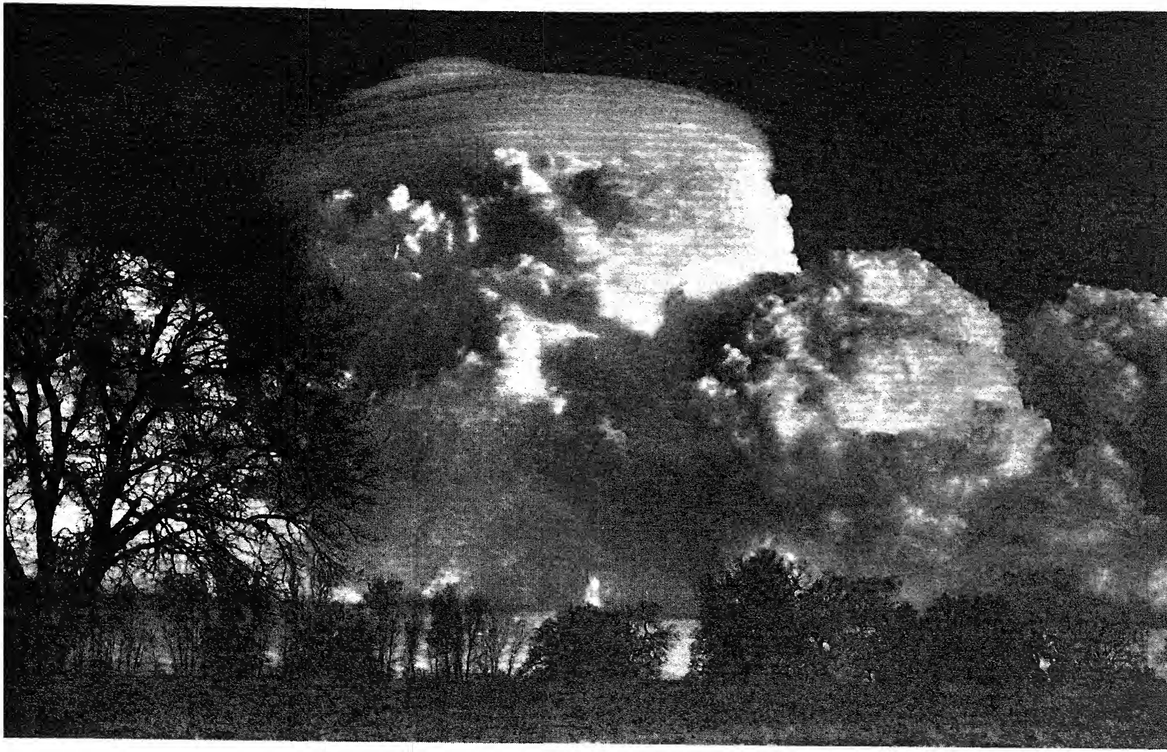


FIG. 20. Scarf cloud above a cumulus. (Copyright 1936, R. H. Sargent)

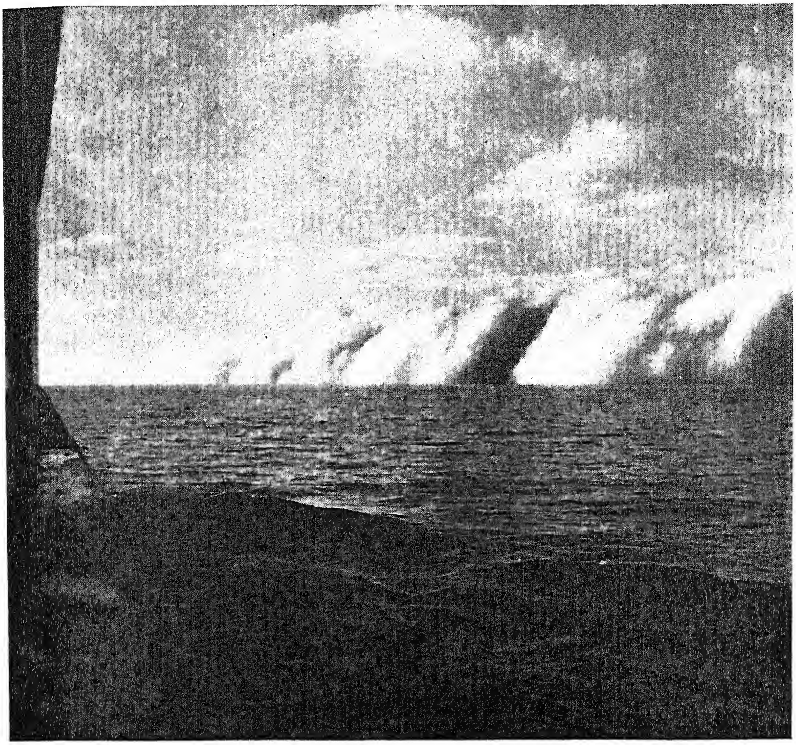


Fig. 21. Fog bank on North Atlantic.

rain between the flat, horizontal base and the distant horizon. The growth of a great cumulonimbus cloud is a magnificent spectacle.

The upward currents in cumulonimbus clouds are sometimes very strong as is shown by the size of hailstones which occasionally fall during thunderstorms. They have been found to weigh a pound or more on some occasions, and have been as large as baseballs or even larger. On July 6, 1928, hailstones "as large as grapefruit" fell at Potter, Nebraska. One was found to be seventeen inches in circumference and to weigh one and a half pounds. The velocity of uprushing air must be very great to support a large hailstone during the process of formation in the high, cold layers of the thunderstorm cloud. It has been calculated that, to

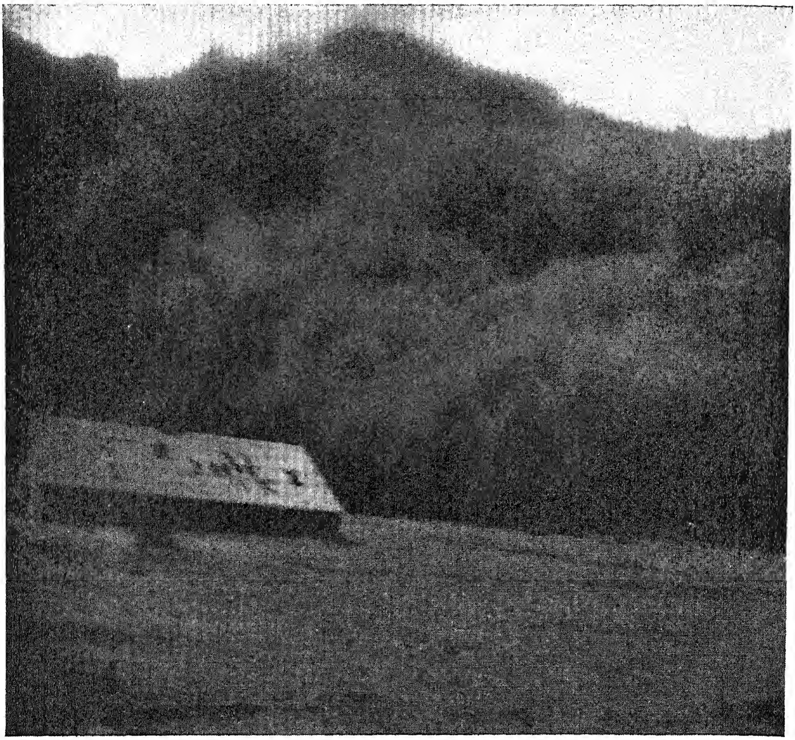


Fig. 22. Duststorm.

support a hailstone three inches in diameter, the vertical velocity of the air would have to be 116 miles an hour.[2]

The cloud tops "tower into regions of extreme cold where the temperature is far below freezing and often even below zero. On mixing with snow they [raindrops carried upwards] freeze as globules of cloudy ice. Getting into descending currents, out of the uprushes, they fall into the rain levels, and take on a clear layer of ice from contact with rising drops; then again the growing hail is tossed on high to receive another coat of snowy ice."[3]

Perhaps the biggest credible story of large hailstones is that

[2] Humphreys, W. J. *Physics of the Air.* New York, 1940.
[3] Brooks, C. F. *Why the Weather?* New York, 1927.

huge blocks of ice, some weighing as much as four and a half pounds, crushed houses at Cazorla, Spain, on June 15, 1829.

Over warm seas, cumulus or cumulonimbus clouds are nearly always in view somewhere. Their outstanding feature is the flat base (Figs. 15, 35). Their tops may be dense and clear-cut or frayed out and irregular, but the bases are flat and dark. The reason for this is that the warm air is being pushed up and it expands and cools as it rises until its temperature gets low enough for the moisture to condense. It is like the steam from a kettle; it comes out in a clear stream until it cools enough for condensation, and beyond that point we see white steam. Everywhere we look it is cool enough for condensation at a definite height above the water, and the flat base of the cloud forms at that level. Just imagine that the ocean is the kettle shooting warm air upward here and there; we cannot see the air until it travels upward far enough for condensation. The flat base is in the shadow of the cloud above, so we see a dark surface that appears as a line in the distance.

All clouds are produced by cooling of air, but after they are formed their sizes and shapes may be affected by warming and drying.

Air may be forced to rise and expand on crossing a mountain, on flowing over another air mass which is colder and heavier; or a moist current may be pushed upward by a growing cumulus (Fig. 20) or even a volcanic eruption (Fig. 19). Condensation in these latter cases forms what is called a "scarf" cloud, which is a kind of lenticular cloud.

Warm air may flow over a cool land or water surface and be chilled so that condensation results; air may lose some of its heat by radiation; air masses of different temperatures may be mixed to produce condensation. In coastal areas, a low, stratus cloud is sometimes formed when the surface layer of a fog bank evaporates and the upper layer remains as a cloud. This last type is called a "velo" or veil cloud; it is often found along the coast of southern California and in other regions near relatively cool water surfaces. When a mass of warm air lies over a cold air mass, the surface between may act as a "lid" or "ceiling." The two layers do not

mix readily and smoke, dust and the products of condensation accumulate there and spread out laterally, forming a stratus cloud. Over cities such a layer may become very dense from the accumulation of smoke from combustion of soft coal.

Whatever the forms that clouds may take, it is easy to see how closely related they are to winds, atmospheric pressure, and the storms. We will have a look at these matters in the next chapter.

CHAPTER III

PREVAILING WINDS, BAROMETERS AND THE LAW OF STORMS

MUCH of our early knowledge of the prevailing winds and currents of the oceans was a product of the researches of Matthew F. Maury, an American naval officer. Early in his career he met with an accident which resulted in permanent lameness. In 1841 he was placed in charge of the depot of charts and instruments which later grew into the Naval Observatory and the Hydrographic Office. Maury then began a systematic collection of observations from seamen in order to show the prevailing winds and ocean currents.

In the stirring days of the American clipper ships and the California gold rush, sailing ships raced around the Horn, setting new records for speed by taking advantage of Maury's charts. And some of these records show that the sailing ship was not a snail in comparison with the steamship. Clipper ships could make a speed of 18 knots, and one clipper made 363 miles in 24 hours. In one year 90,000 passengers were carried to California around South America on clipper ships. The great armada which carried invasion forces to North Africa in November 1942 numbered 350 warships and 500 other ships. By comparison, during the gold rush there were at one time 500 ships in the bay at San Francisco deserted by sailors who had gone to the gold fields.

The gold rush maritime commerce was merely the most striking illustration of the value of Maury's charts. They won him an international reputation. He has been called the "Pathfinder of the Seas." Although modern ships are not dependent upon the wind for power, there is scarcely a steamship today without pilot charts, and every such chart of the U.S. Hydrographic Office bears in the margin a notation: "Founded upon the researches made in the

early part of the nineteenth century by Matthew Fontaine Maury, while serving as a lieutenant in the United States Navy."

If we examine the wind arrows in Figures 23 and 24 we see at a glance that there are certain belts around the world, each with a wind system more or less different from the others. Between the Equator and 20° north latitude in Figure 23 we see that the heavier arrows point generally away from the east or northeast, while in a similar belt (0° to 20°) south of the Equator the heavier arrows point generally away from the east or southeast. These are the trade wind systems, with northeast winds (*from* the northeast) above the Equator and southeast winds (*from* the southeast) below the Equator—"the northeast and southeast trades."

Farther from the Equator in each hemisphere, we find lighter arrows pointing more or less away from the Equator and to the right (to the east). These are the *prevailing westerlies*.[1] The heavy arrows indicate steady winds; light arrows indicate changeable winds. By reference to Figures 6 and 7 we see that the prevailing westerlies are stormy, especially in winter, while the trade winds are rarely stormy.

There is a narrow belt near the Equator where the northeast and southeast trade winds come together; this is a belt of frequent calms called the doldrums. Of course there is no calm on the deck of a steamship as it passes through the doldrums but the traveler can generally recognize it by the appearance of the sea surface, without whitecaps, the frequency of showers, and the heat and humidity. If not, he can associate it in his mind with the visit of "King Neptune" who—at least on a peacetime voyage—comes on board near the Equator and initiates those who are crossing the line for the first time. About the time that "King Neptune" and his "Court" have finished the initiation and perhaps a few of the bolder passengers have seized the "King" and thrown him into the swimming pool, we are passing from the northeast trades into the southeast trades, with the doldrums between.

[1] The region of light winds between the trades and the prevailing westerlies is called the "horse latitudes."

These are the prevailing or average conditions, but the winds are not altogether steady even in the trades, so there may be some variation on any given day. In fact, it is sometimes the experience of the traveler who goes around the east coast of South America, for example, that northeast winds are felt all the way to Buenos Aires and for the time being there is no definite doldrum belt. On the average, however, the winds of the oceans during the northern winter are as shown in Figure 23.

Regardless of the speed of the steamship, there is some importance attached to the prevailing winds. It is somewhat similar to a trip by train. We get aboard in hot weather and select a seat on the shady side. Soon the train starts and by the time it is out of the city we may be turned around and the sun may be on our side while the passengers who knew the road, or thought about it in advance, may now be on the shady side.

Similarly, if we go from New York to Capetown, South Africa, we find after we are two or three days out of New York that the prevailing winds are from the east-northeast above the Equator and southeast below. If we are on the starboard or west side, we will sleep hot nearly all the way down, while the port side is cool. Coming back the condition is reversed. In other latitudes and on other voyages it may be cold and we may not wish to be on the windy side.

The movement of the ship causes the wind to come from a point farther toward the bow than the true wind but never causes it to come from the other side of the ship. For example, if the ship is headed south at fifteen knots and the wind over the sea is coming from the east at fifteen knots, the wind on the deck will seem to come from the southeast. The faster the ship moves, the farther forward the wind is but it never goes over to the other side of the ship unless the wind changes or the ship takes a new course. So we can look at the wind charts and see which side of the ship will have the wind.

If we examine the wind chart for the northern summer, Figure 24, and compare it with the winter chart, we see that there have been some changes. In general, the doldrum belt, where the trade

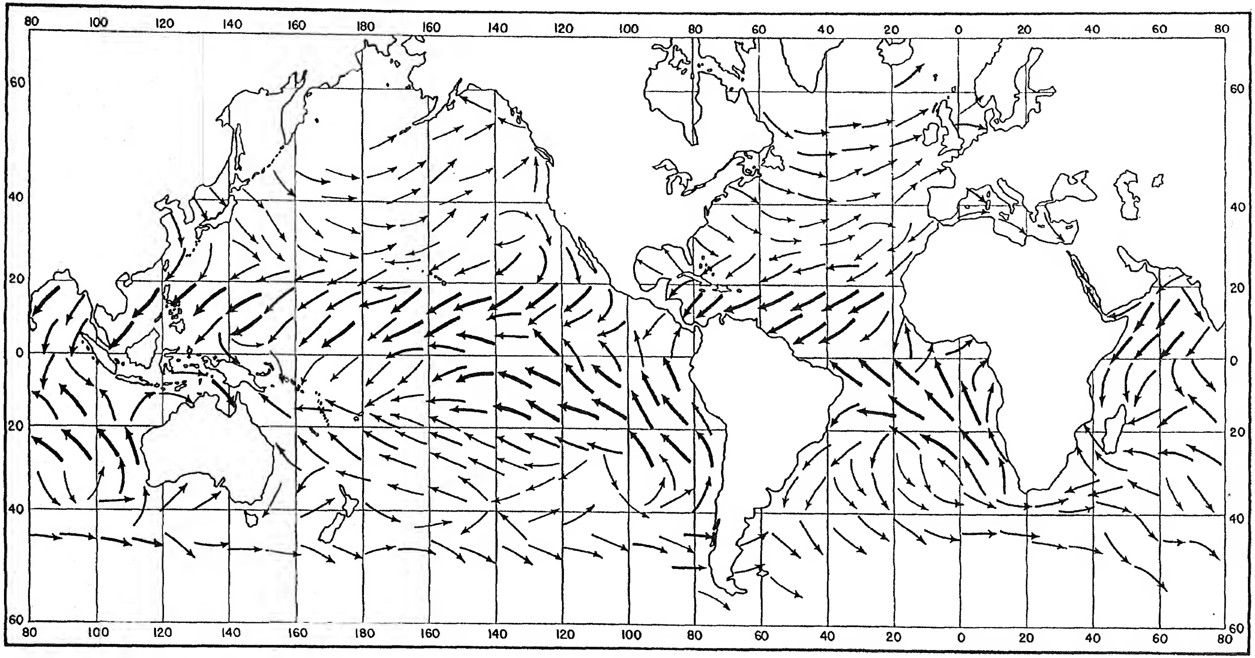


Fig. 23. Prevailing winds in January. Arrows fly with the wind; for example, if the arrow points toward the southwest, the wind blows from the northeast toward the southwest and is called a northeast wind. The heavier the arrow the more constantly the wind blows from the direction indicated. The arrows do not give any indication of the velocity of the wind. For frequency of gales see Figures 6 and 7.

winds converge, is father north in summer than in winter. The southeast trades in the Atlantic extend north of the Equator. There are differences elsewhere, notably in the region east of Africa and south and east of Asia where the wind directions are reversed from winter. These are the monsoons. In general they are steady winds, blowing *out from* Asia in winter and *into* Asia in summer.

While the wind charts show the prevailing winds on the open ocean, they are not intended to be an indication of the winds on the immediate coasts. In many parts of the world there are local land and sea breezes on the coasts. At night the air over the land cools faster than the air over the sea, so the cool air flows over the coast and out to sea. Toward noon the air over the land, which gets warm faster by day than the air over the sea, is pushed out of the way by the cooler sea air and a sea breeze comes in. The reason for this is that the temperature of the water changes more slowly than the temperature of the land.

What actually takes place is this: When the air over the land is heated in the morning, it expands and some of the air is pushed upward. There is then more air in the upper levels over the land than over the water, so some of the air above flows out over the sea. Then, in turn, the air accumulates above the sea surface and it becomes heavier at the bottom and pushes in from the sea surface to the land, making a sea breeze. Thus, there is a movement of air *from* the sea at the surface and *toward* the sea above. At night when the land breeze blows at the surface, there is a corresponding motion in the opposite direction above. The sea breeze is somewhat like air movement caused by a radiator which heats the air in the room; the warm air is pushed up toward the ceiling and flows outward above while cooler air flows across the floor toward the radiator.

The sea breeze is very important in some places. The morning hours on shore are very hot and the coming of the sea breeze is a great relief. In hot climates, rooms opening toward the sea are usually at a premium. Where there are strong prevailing winds, as on some of the islands in the trade wind belts and on coasts with monsoons, the sea and land breezes are not developed but there

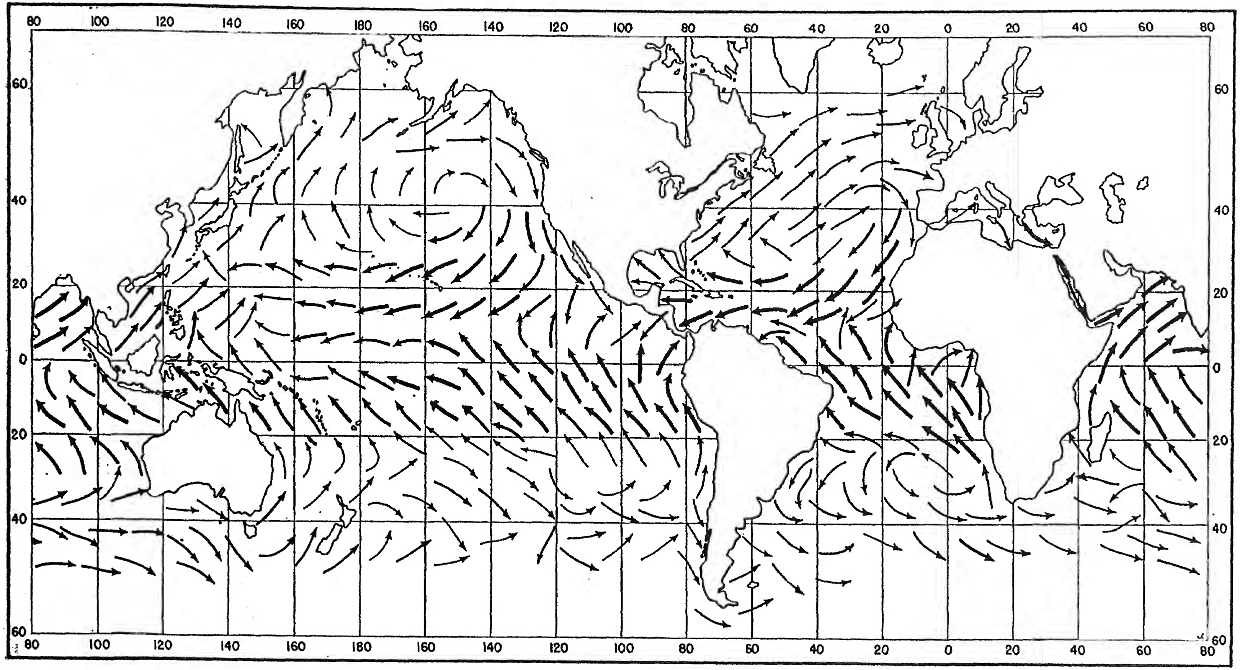


Fig. 24. Prevailing winds in July. Arrows fly with the wind; for example, if the arrow points toward the southwest, the wind blows from the northeast toward the southwest and is called a northeast wind. The heavier the arrow the more constantly the wind blows from the direction indicated. The arrows do not give any indication of wind velocity. For frequency of gales see Figures 6 and 7.

is some variation in the direction and force of the winds from day to night.

Land and sea breezes are especially well developed in some localities where there is a desert or semi-desert very near the coast so that there is a large variation of temperature contrasts and well developed land and sea breezes. Valparaiso in summer is a good example. Maury[2] described it as follows:

"In the summer of the southern hemisphere the sea breeze at Valparaiso is more powerfully developed than at any other place to which my services afloat have led me. Here regularly in the afternoon, at this season, the sea breeze blows furiously; pebbles are torn up from the walks and whirled about the streets; people seek shelter; the Almendral is deserted, business interrupted, and all communication from the shipping to the shore is cut off. Suddenly the winds and the sea, as if they had again heard the voice of rebuke, are hushed and there is a calm. The lull that follows is delightful. The sky is without a cloud; the atmosphere is transparency itself; the Andes seem to draw near; the climate, always mild and soft, becomes now doubly sweet by the contrast. The evening invites abroad, and the population sally forth—the ladies in ball costume, for now there is not wind enough to disarrange the lightest curl. In the southern summer, this change takes place day after day with the utmost regularity, and yet the calm always seems to surprise, and to come before one has time to realize that the furious sea-wind could so soon be hushed."

Effects such as this described by Maury, as well as the many other air movements, are now known to reflect differences in the weight of air above the earth at various points. We determine these differences by use of a barometer, a device for measuring the weight of the air above us. When we weigh anything, we balance it against a known weight and that, indirectly, is what we do with a barometer. Air is very light in weight, consequently the total amount above us, from the very top of the atmosphere down to sea level, is only about 14½ pounds to the square inch. We bal-

[2] Maury, M. F. *The Physical Geography of the Sea.* 15th Ed. London, 1874.

ance it against a column of mercury, which is very heavy, so that a column of mercury an inch square and weighing 14½ pounds would be a little less than 30 inches high.

The ordinary seagoing barometer is an aneroid. It does not contain mercury. Like the butcher who weighs your meat with springs, the mariner usually weighs the atmosphere by using springs instead of weights.

At the center of a storm there is less air above us than in ordinary weather. When there is less air, the pressure is naturally less and the barometer is low. Air flows from high to low pressure just as water runs down hill. But even as it flows from high pressure toward low pressure in a storm center, the amount of air at the center may become less. The explanation of what becomes of the air in a storm center, when the barometer falls with air directed inward from all sides at the earth's surface, is one of the problems of the meteorologist. Somewhere aloft it is carried away but we have not accumulated many observations in the upper air during stormy weather and we do not fully understand the entire process.

Air does not move directly from high to low pressure. Whenever air moves across the surface of the earth, it is subject to a deflective effect due to the earth's rotation, to the right in the northern hemisphere and to the left in the southern hemisphere. If there is a tendency for the air to move from the Equator toward the north, the deflective effect results in a wind from the southwest toward the northeast, turning toward the right. If we look at the wind charts, Figures 23 and 24, we see that the northeast trades are winds which tend to move toward the Equator but, owing to the earth's rotation, they become northeast winds, turning to the right, while the southeast trades are winds which tend to move toward the Equator but turn toward the left. All winds over the earth's surface, no matter what their direction, are subject to the same effect of earth rotation.

A Dutch physicist named Buys Ballot, in 1857, stated a famous law which is as follows: If in the northern hemisphere you stand with your back to the wind, pressure is lower on your left hand

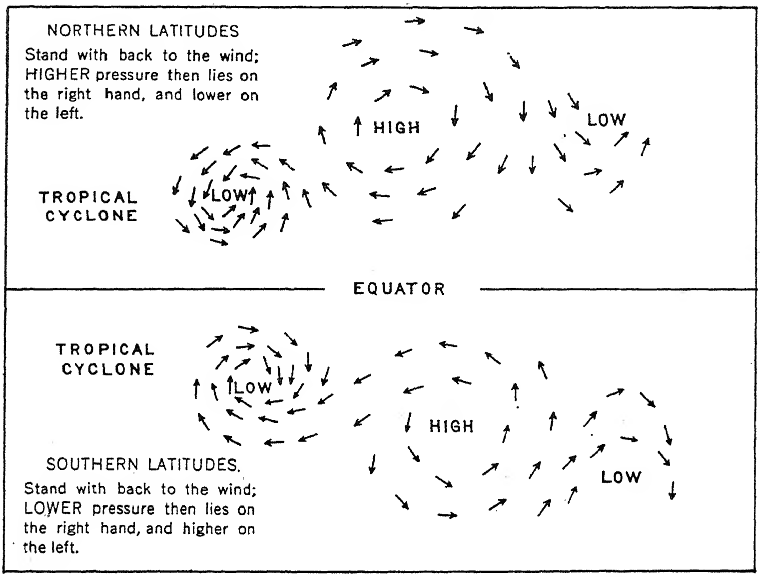


FIG. 25. Wind circulation in high and low pressure systems.

than on your right. In the southern hemisphere the reverse is true, for if you are south of the Equator and stand with your back to the wind, pressure is lower on your right hand than on your left. This is a useful law. If there is a storm in the neighborhood, we stand with our back to the wind and the storm center is on our left when we are north of the Equator and on our right when we are south of the Equator, as shown in Figure 25. When we are on a moving ship we must stand with our backs to the *true* wind.

Wind systems with low pressure at the center may be given any one of several names such as *lows, depressions, cyclones,* or *disturbances.* High pressure systems are called either *highs* or *anticyclones.* In the anticyclone or high, the air tends to move outward from the center and its wind circulation is more or less the reverse of that in the cyclone, as is shown in Figure 25.

A storm experienced at sea is nearly always a part of a low

pressure system with an indraught of air around the center; the exceptions are thunderstorms and purely local winds. A "cyclonic storm" is a low or disturbance or cyclone with a system of strong or dangerous winds. We talk about the "law of storms" but really there is no such thing. When men were first beginning to learn something about the winds in storms, they put down what they knew and called it the "law."

By the middle of the nineteenth century there were a few books on the "law of storms" for seamen, telling how to avoid them. Some ship captains of that day did not want to maneuver to keep away from a storm. They claimed that maneuvering to avoid a storm delayed them and how would they explain the delay to the owners with no record of a storm in the ship's log!

CHAPTER IV

OCEAN CURRENTS, TEMPERATURES AND CLIMATE

Owing primarily to the sun's heat and the rotation of the earth, the sea is always in motion. The heat of the sun causes differences in temperature, winds, rain and snow. Waves and currents result. Like great rivers, the principal currents transport vast quantities of cold water from the polar regions toward the Equator and from equatorial regions toward the poles. The best known of all these currents is the Gulf Stream. Other important currents are the Equatorial Currents and Counter Currents, the Kuroshio or Japan Current, and the West Wind Drift of the southern oceans. There are also the Labrador Current; the Current of Peru (Humboldt) off western South America; the Benguela Current along the west coast of southern Africa; the Agulhas Current off the east coast of southern Africa; the California Current; the Falkland and Brazil Currents off eastern South America; the Alaska Current, and many other less important currents.

All of these currents have important general or local effects on climate, including cloudiness, storminess, and rainfall, and on the temperature of the atmosphere which overlies the oceans and the adjacent continental areas. Broadly speaking, ocean currents distribute heat and stabilize the temperatures of the world, but they also produce great extremes of rainfall in land areas nearby.

The surface currents of the ocean depend on the prevailing winds, differences in density of seawater, and a number of other factors. The effect of prevailing winds is made evident by an inspection of a chart of ocean currents, such as Figure 26, and a comparison with the wind charts, Figures 23 and 24. On the wind charts the trade winds are shown roughly by the heavier wind arrows, except in the seas east and south of Asia, where they

represent the monsoons. In general, the trade winds cause currents from east to west. This actually causes an accumulation of water in the western parts of the oceans and the winds blow slightly uphill. Between the trade winds north and south of the Equator there is no wind in the belt of calms, and a counter-current runs from west to east.

The effect of wind on the ocean surface is complicated by a number of factors. First, the wind causes a movement of the water which in the northern hemisphere is deflected to the right as a result of earth rotation, to the left in the southern hemisphere; water accumulates to the right or left, depending on the hemisphere, and this difference in level produces a compensating return flow, so that the net result is that the current tends to move more or less with the wind. Continental shores and local variations of the winds near the sea surface make the problem very difficult and at present oceanographers have only an approximate solution.

Ocean currents have important influences on climate. An example is the climate of the west coast of South America, which is discussed in Chapter IX. The Humboldt Current, or Current of Peru, flows northward along the west coast of South America. It is a cold current which favors the formation of stratus cloud or fog but which is not favorable for rising air currents or the formation of clouds of the cumulus type from which much of the rain of the tropics falls. Cloudiness and rainfall, as shown in Figures 29 and 30, exhibit the effects of this current.

There is an upwelling of the water along the coast and this, in combination with the movement into warmer latitudes, maintains surface temperatures that are lower than the temperature of the air. This is especially true in summer, when, because of the cool water, there is cloudy weather with little rain or none at all, hence the coastal regions of Peru and northern Chile are largely deserts.

At intervals the Humboldt Current is replaced by a warm current (called El Niño) from the north; this happened in 1891 and again in 1925 and 1941. The advent of the warm current is attended by heavy rains. The traveler can see the deep gulleys and ravines caused by heavy rains in a region that is normally desert.

Along the west coast of South Africa there is a similar movement of relatively cool surface water which is called the Benguela Current. The neighboring coasts are dry. A comparison of the current chart (Fig. 26) with the rainfall chart (Fig. 30) shows that there is a deficiency of rainfall over the ocean where this current sets northward and northwestward to the Equator, but this is not unexpected in a region dominated by trade winds. We find somewhat similar conditions along the coast of southern California and Lower California (the California Current) and along the northwest coast of Africa.

It is rather astonishing to find islands far out in the ocean with desert conditions along their shores, but unless the winds over cool currents strike elevated lands there is very little rainfall. The islands of Ascension and St. Helena, both in the tropics, are remarkably dry at sea level. On Ascension the annual rainfall near the sea is only about 5 inches, but exceeds 25 inches at higher levels. St. Helena has an annual rainfall of only 6 inches at low levels and the coastal areas are barren; at a height of 2,000 feet the annual rainfall is 40 inches. The Galapagos Islands, near the Equator in the Pacific west of Ecuador, are washed by an extension of the Humboldt Current and have a mean annual temperature of 72° which is low for the tropics. In these islands very little rain falls near the sea; the shores are semidesert with cactus and thorn trees.

The most important of all currents is the Gulf Stream and its extension, known as the North Atlantic Drift. It results only in part from wind drift; the difference in density of the water is thought to be the primary factor in maintaining the circulation. The Gulf Stream spreads out fanwise from Florida and becomes a broadening Atlantic drift as it approaches northern Europe. This drift water is relatively warm, especially in winter. Its effects in producing rainfall over the North Atlantic are evident in Figure 30, where a shaded rainfall area begins near Florida and widens toward the northeast.

It will be noted, also, that there is a broad indentation in the

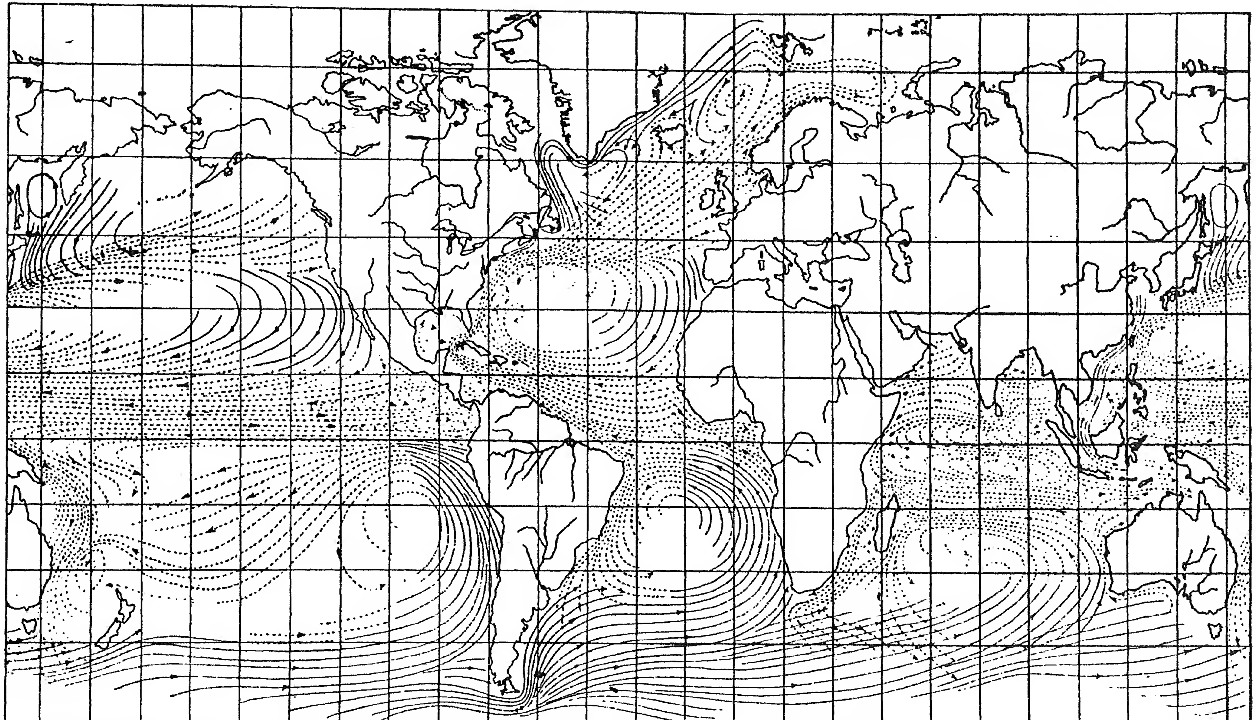


FIG. 26. Ocean currents. Cold currents, solid lines; warm currents, dotted lines. Arrow heads indicate direction of movement of water.

shaded rainfall area where the cold Labrador Current flows southeastward in the vicinity of the Grand Banks.

The warmth of the Gulf Stream and of the drift water of the northern North Atlantic is one reason why the cyclonic storms of the North Atlantic are so vigorous. Another result is the mildness of winter in northwestern Europe.

A similar but less important current is found in the North Pacific; it is called the Kuroshio or Black Stream. It flows northeastward from Japan and is distinguishable by the darker color of its waters.

An oddity in the midst of three ocean currents is the Sargasso Sea. It is in the North Atlantic Ocean, approximately between 25° and 30°N and between 40° and 70°W. A large area covered by floating seaweed, its extent is somewhat variable. The weed is yellowish in color and has small berry-like bladders. At one time it was believed that the weed came from the Antilles but it is now generally considered to be a product of the sea. Contrary to the belief expressed by early navigators, the weed does not interfere with the movement of ships. It was here that Columbus nearly had a mutiny on his hands because the sailors saw the seaweed and thought the boats were about to run on the rocks. Actually, the ocean here is, roughly, four miles deep.

The main routes from the British Isles to the West Indies and from New York to Capetown, pass through the Sargasso Sea. Generally, its surface waters are nearly motionless, but they are surrounded by the surface currents of the Gulf Stream, the Canary Current, which is west of northern Africa, and the North Equatorial Current, as is evident in Figure 26, where the North Atlantic region without any arrows is roughly the position of the Sargasso Sea.

CHAPTER V

HEAT AND HUMIDITY

As far as human comfort is concerned, temperature is the most important weather element. Storms, rough seas and rainy weather may be of great concern for the time being but air temperature affects us every moment. The clothing we wear or the baggage we carry is largely determined by the temperature. Fortunately, on the oceans and in the majority of large cities of the world, we spend nearly all of our time in marine climates where variations of temperature are relatively small.

The human body is very sensitive to changes of air temperature. Nearly half of civilized man's hours awake are required for adjustment to the temperature of the air. We spend an appreciable share of our time in taking off and putting on clothing and in other activities in an effort to be comfortable in every new situation in and out of doors. If we add to this our changes of clothing with change of season or climate, plus the job of finding shelter and heat, and the time taken up by related activities of purchase and transportation of these effects, we get some idea of the importance of air temperature.

But temperature, as we have seen, is also an important element in the whole complicated mechanics of winds, precipitation, and in fact most of the weather phenomena with which we are concerned. Whether we are interested in temperature for itself or as related to other factors, about the most important fact about a place is what the thermometer tells us.

From a study of simple monthly records of mean or average temperature and rainfall we can gain a general idea of the climate.

The mean temperature is obtained by one method, by taking the average of the twenty-four hourly temperatures to get the temperature for the day and then taking the average of the daily temperatures to get the monthly mean. A result that is about as

good for practical purposes is to add the highest and lowest temperatures of the day and take half the sum to get the mean. Thus, if the highest temperature of the day is 80° and the lowest 70°, the mean is half-way between, or 75°.

In all parts of the world, temperatures of the air are taken from shelters which allow a free movement of the air but prevent the sun from shining directly on the thermometers. Thus the conditions of measurement are substantially the same nearly everywhere and, with few exceptions, the official temperatures which are recorded in any part of the world may be compared with the records kept in other places.

On the other hand, the mean is not entirely satisfactory as an indicator of temperature. For example: Lisbon and Los Angeles have almost exactly the same mean temperature in May, and again in August. In May the mean temperature at both places is about 62° but the average daily high temperature in Lisbon is 66° while at Los Angeles it is 72°. The average low temperature at night in May is 58° at Lisbon and 52° at Los Angeles. In August both places have a mean temperature of 71½° but in Los Angeles the range is from 82° to 61° and at Lisbon 76° to 67°. The range at Los Angeles, in other words, is 12° more than at Lisbon. This is an important factor; the days in Los Angeles are much warmer and the nights much cooler than in Lisbon.

On the continents, and especially in deserts, the daily ranges are far greater than they are on the oceans. As an extreme case, In Salah in the Sahara Desert has a mean temperature in July of 99° and the daily range there is 35°—from an average daily high of 117° to an average low at night of 82°.

What do these temperatures indicate, so far as human comfort is concerned? What is the ideal temperature?

Many Americans go to southern Florida in winter and to New England in summer to escape the extremes of temperature at home. At Miami the mean temperature in winter is 68°; in New England the mean temperature in midsummer is very nearly the same. The ideal temperature for an American, if any can be considered ideal, is about 68°. It is the temperature of late April and

early May in the Gulf Coast States, the temperature of late May and early June in many of our northern States, and the temperature of New England and northern Michigan in midsummer. For physical exercise out of doors, of course, the temperature should be somewhat lower; some investigators have concluded that it should be about 60°.

Many tests have been made to determine the most favorable temperature for American workers in mines and factories. This is called the "optimum" temperature. It is interesting to note that in some tests of this kind men have been subjected to air temperatures as high as 240° to 260°. They have been confined in saturated air at temperatures ranging from 90° to 100° for considerable periods in order to note the effects and compare them with reactions to other temperatures. After tests at many different temperatures and humidities, the general conclusion is that the optimum is somewhere between 65° and 69°, with humidity around 70 per cent and with an appreciable movement of the air.

Studies of the effects of temperature on American school children have led investigators to the conclusion that, with the right condition of humidity, the proper temperature for the schoolroom is 68°.

Climatologists generally accept 68° as the mean annual temperature of the borderline between the tropical and the temperate zones of climate.

Humidity, under some circumstances, is almost as important as temperature. Air movement is also important. Within certain broad limits a rise of temperature above the optimum is not unfavorable if the rise is accompanied by a lowering of the humidity and a free movement of the air. Likewise, for bodily comfort, a lowering of the temperature below the optimum should be accompanied by increased humidity and lessened air movement.

In China during hot weather, the loosely dressed natives in lightweight clothing find temperatures of 90° to 95° not unpleasant, provided that the humidity is not over 30 per cent and that there is a good movement of the air.

On the other hand it seems that when the air becomes very hot

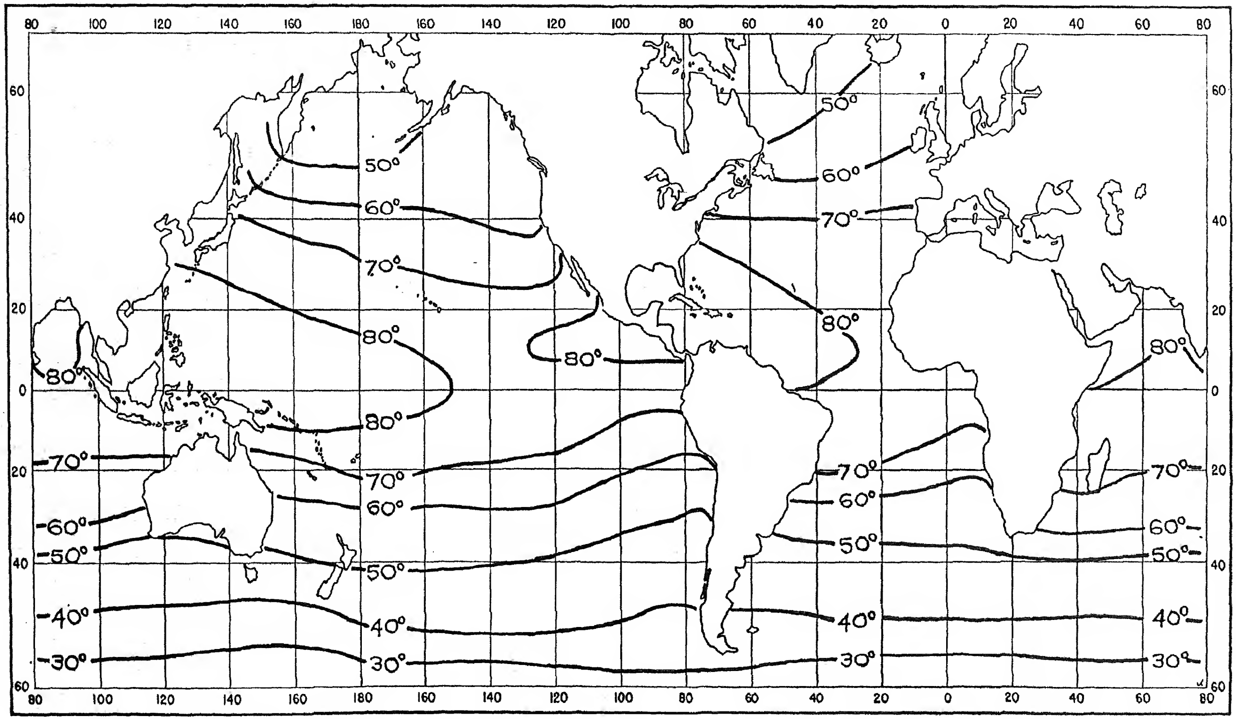


FIG. 27. Mean isotherms for the oceans in July. Lines are drawn through regions having the mean temperatures shown on the lines.

it may reach a point where increased wind movement does not increase the rate of evaporation from the skin and hence the wind is irritating. On a ship steaming through the heat of the Red Sea, passengers are sometimes obliged to seek refuge from the breeze. Also, the adverse effects on the nervous system of dry winds in the lee of mountain ranges, are well known. Cases of suicide have been attributed to the effects of these winds.

At low temperatures, humidity is of little consequence but air movement may be of great concern. At Verkhoyansk, Siberia, the world's coldest spot, the thermometer registers as low as 80° below zero nearly every year; the lowest of record there was 94° below zero. Such temperatures are not especially troublesome to the natives because extremely cold weather is not attended by any wind movement. The breath freezes and falls as a white powder. However, at temperatures only slightly below zero, a snowstorm is very trying on the natives. Wind movement is hard for them to endure at low temperatures.

In moist tropical regions, high humidity is unfavorable. Continued residence in such a climate lowers the vitality of an American and robs him of his resistance to disease. The drier climates of the tropics are more favorable.

Persons living in the humid tropics become sensitive to slight temperature changes. Although there is no winter, so that the mean temperature from season to season changes very little, the difference of temperature between day and night is sufficient to affect the natives considerably. For this reason it has been said that night is the winter of the tropics. For example, at Bolobo, Congo, the average daily range of temperature is 16°, but the annual range from the warmest to the coolest month, as an average, is only 2°.

The change in temperature of the sea surface from day to night and from summer to winter is rather small. From day to night it averages less than a degree Fahrenheit in the open sea, but on large ships it is considerably more, especially in clear weather because of the heating of the decks and superstructure. The warmest parts of the Indian and Pacific Oceans average 82° to 84° the

year round. The difference between summer and winter is greatest at about 40° north latitude where the average range is 18°. Water temperatures reaching 90° are frequent in the western part of the tropical Pacific; the Persian Gulf reaches 96° in summer and the Red Sea reaches 94°.

It is a surprising fact that even in tropical waters the air at night feels cold to one who is continuously exposed to it. Eddie Rickenbacker said that while floating on a life raft in the South Pacific in October 1942 he came to hate the nights. By day the sun burned fiercely. His body blistered and turned raw and burned again. He longed for the night but it seemed worse than the day. Waves slopped into the raft and though in reality the air and water were warm they felt like buckets of ice water.

Normal sea water freezes at about 28°. When polar bays and gulfs freeze, the air above may become very cold just as in the case of an arctic land area.

Mean temperatures over the oceans for July and January[1] are shown on the charts in Figures 27 and 28. In Table I in the Appendix the average daily high and low temperatures for each month are given for 110 representative cities whose locations are shown in Figures 54 and 55. If the mean temperature for any month is required, it is easy enough to take the sum of the high and low temperatures and divide by two.

Mean temperatures are given in Table V of the Appendix for 75 supplementary stations whose locations are shown in Figures 54 and 55.

In order to indicate the probability of extreme temperatures, Table II in the Appendix gives the highest and lowest of record for each month of the year. It is not at all likely that we shall experience such extreme temperatures on a short visit to a place. As a rule the extremes given in the table have been recorded only once or twice in a long period of years during the month indicated.

[1] In the interior of the continents July is usually the warmest month and January the coldest. There is a greater lag in heating and cooling of water than land so that over much of the oceans September is the warmest month and March the coolest.

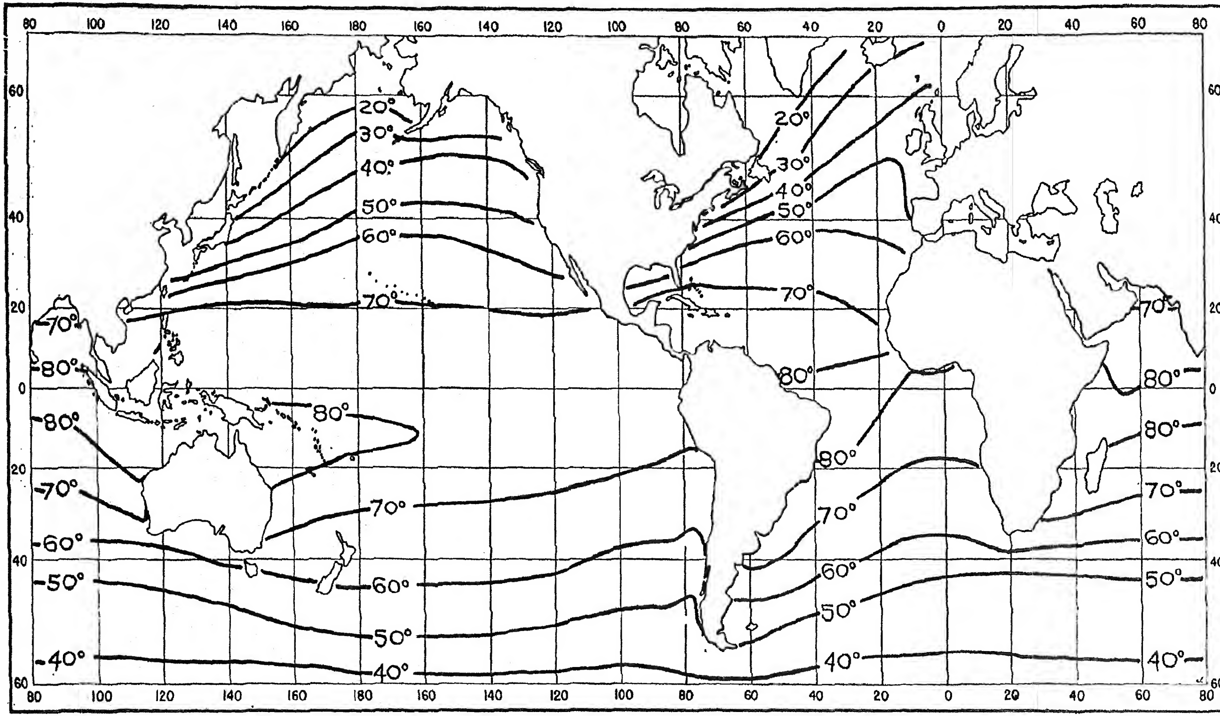


Fig. 28. Mean isotherms for the oceans in January. Lines are drawn through regions having the mean temperatures shown on the lines.

For example, the extremes at New York in August have been 102° and 51° but such temperatures are very rare in that month.

A record of extremes gives some indication, however, of the likelihood of temperatures considerably above or below the average.

Good examples are Guayaquil and Jerusalem. Both have a mean temperature in July of 76°. The extremes of temperature at Jerusalem in July have been 106° and 51°; at Guayaquil in the same month the extremes have been 88° and 66°. The chances of a traveler experiencing a temperature near or above 100° at Jerusalem in July are good if he stops there two or three weeks, whereas at Guayaquil a temperature as high as 90° has never been recorded. But there are other factors. The humidity at Guayaquil in July is 79 per cent; at Jerusalem 49 per cent. Doubtless most of us would prefer the weather in July at Jerusalem. The skies there are almost cloudless, it never rains, and it is cool at night. At Guayaquil the high humidity is oppressive; it is nearly always cloudy and rain frequently threatens though very little falls in July.

The average humidity is given in Table I for each month of the year at 110 cities.

CHAPTER VI

CLOUDINESS, RAIN, SNOW AND FOG

Under most circumstances we find that plenty of sunshine is an asset. This is especially true in mild or cool climates. Near the Equator, however, the glare and heat of the tropical sun are sometimes objectionable. Under such conditions cloudy weather may be more pleasant than sunshine.

There are instruments for measuring sunshine automatically, but records of this kind are not universally kept. In order that comparable records may be presented it is necessary to give cloudiness instead of percentage of sunshine; the proportion of sky covered by clouds is readily observed and averages determined from such observations are generally available for all parts of the world.

Cloudiness expresses the absence of sunshine, but only partially. If the sky is cloudy half of the time it must not be assumed that the sun shines only half of the time it is above the horizon. It often shines through thin clouds. For comparative purposes, however, Table III in the Appendix gives the average percentage of sky covered by clouds for each month and this may be taken as a guide to the amount of sunshine.

If we look in Table III for average cloudiness, less than 40, we find it at places that everyone knows to be famous for their sunshine. This includes the lands bordering the Mediterranean in July and August, southern California in summer and autumn, and the coasts of India and China during the northeast monsoon from November to March. Places with cloudiness above 70 take in most of northern Europe in winter, including the British Isles and especially Scotland, also the coasts of India and China during the southwest monsoon, and the coast of Peru from June to October.

In books on climate we usually find the amounts of rain and

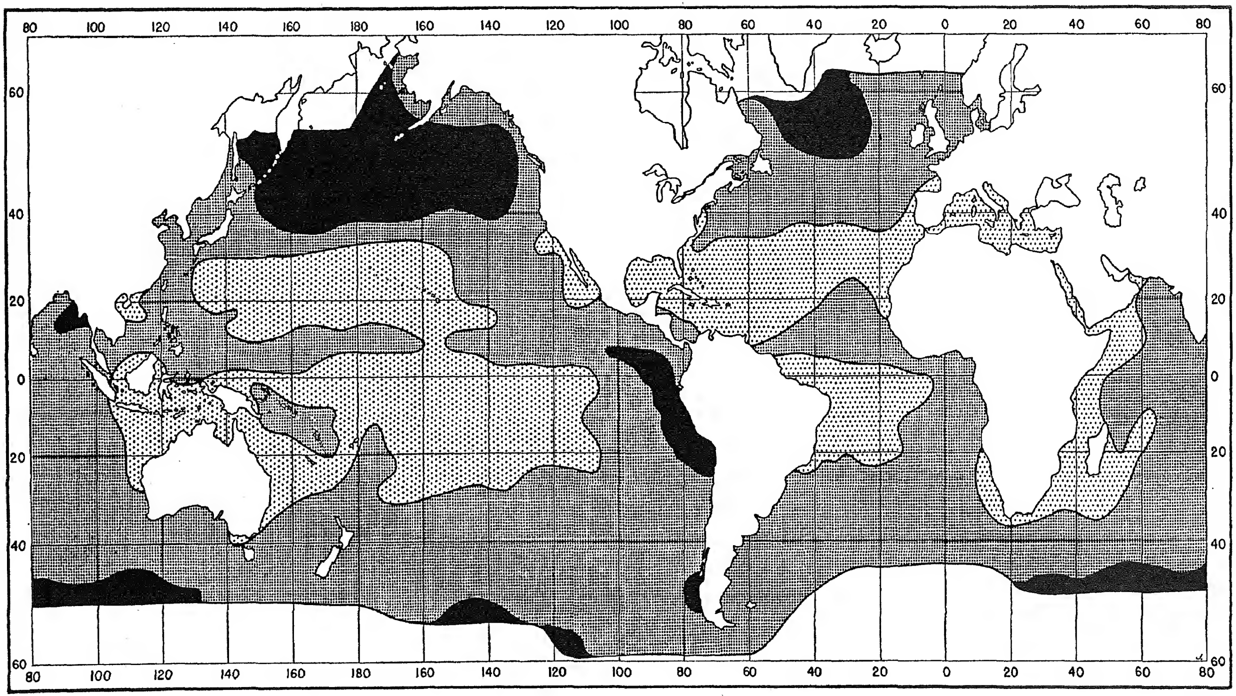


Fig. 29. Average cloudiness in June, July and August. Solid black, more than 70 per cent; heavy stippled areas, 50 to 70 per cent; light stippled areas, less than 50 per cent; data not shown for continents and not available for ocean areas in white.

snow given for each month of the year, but we are not interested in the amount that falls so much as the frequency. We want to know how many days in the month are likely to be marred by rain or snow. Of course any tabulation of this kind has its limitations, for a day with rain is one with more than a certain small amount (usually 0.01 inch), hence the days with heavy rains and those with light showers are tabulated together. In general, rain in hot climates and at warm seasons in temperate climates is in the form of showers and of shorter duration than rain of the cold season. In the tropics much rain can fall in a short time and then the sun is out again.

The importance of the record of rainy days is apparent from an examination of Table III, where we see that there are a number of places where the average is 25 rainy days in a month at certain seasons. At Cristobal in the Canal Zone it rains 25 days a month in July, August, and November, while at Para, near the mouth of the Amazon in Brazil, it rains 27 days a month in January, 26 in February (all but two!), 28 in March, and 27 in April. Other rainy places are the northwest coasts of North America and the British Isles in winter, and the coasts of India and China and the adjacent seas during the southwest monsoon.

Table V in the Appendix gives the average amount of rain by months, and for the year, at 75 selected places, mostly in the interior of the continents.

Figure 29 shows cloudiness over the oceans in summer of the northern hemisphere (June, July and August). In the northern winter, cloudiness has about the same distribution except that there is considerably more over the North Atlantic from New York to the British Isles and less in the tropics just west of South America; there are also the monsoonal variations previously noted near the coasts of India and China.

Figure 30 shows the frequency of rainfall, also in the northern summer. In the northern winter there is more rain over the northern oceans and less over the southern.

In Figure 30, the belt of doldrums is shown by the black strips of heavy rainfall just north of the Equator in the Atlantic and

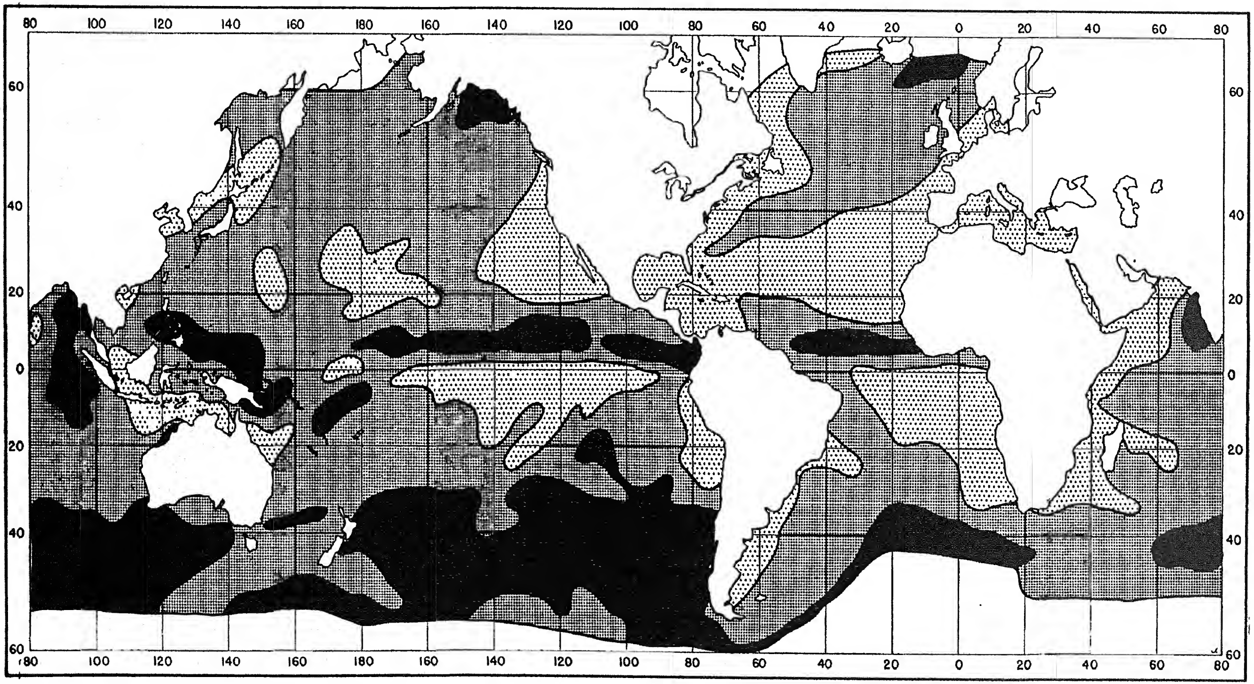


Fig. 30. Percentage frequency of rainfall in June, July and August. In solid black areas, rain falls more than 20 per cent of the time; heavy stippled areas, 10 to 20 per cent; light stippled areas, less than 10 per cent; data not shown for continents and not available for ocean areas in white.

eastern Pacific. Figure 29 shows the cloudiness in this belt to be in excess of that in the regions of the trade winds.

Cloudiness and rainfall, as depicted here, are from a compilation of 5½ million weather observations taken by seamen during approximately half a century, and recently summarized and charted by the Weather Bureau.[1]

In some places in the tropics and sub-tropics rainfall in a single day may exceed a whole year's normal fall in temperate latitudes. As an average, San Francisco has 22 inches, Chicago 33 inches, London 25 inches in a year. The world's record for 24 hours is 46 inches which fell at Baguio in the Philippines on one day in July 1911. During the same storm an additional 42 inches fell at the same place, making a total of 88 inches in four days. There are many other places where amounts ranging from 20 to 40 inches have fallen in one day. Silver Hill, Jamaica, had 96.5 inches in four days and Funkiko, Formosa, 81.5 in three days.

Porto Bello on the Atlantic coast of the Canal Zone has an average of 48 inches in October and November together and has the record for a short-period rain—2.47 inches in three minutes on November 29, 1911. In two hours on that day the rainfall measured 6.31 inches.

Some writers think that it is an advantage that in many places in the tropics rain falls nearly always at about the same time of day so that we can be on the lookout for it. That may be true to some extent but one trouble is that we don't know just *how much* will fall. Two or three inches may be very annoying, even if we expect a shower. Certainly it is the unexpected, either in time or amount, that makes rainfall unpopular. One classic example of an untimely rain is that which fell on the 16th and 17th of June in 1815 at Waterloo. Victor Hugo in *Les Misérables* says that rain defeated Napoleon. There was a mild thunderstorm on the night of the 16th and a heavier shower on the 17th. On the morning of the 18th the corn fields were soggy and the roads muddy and the French advance was delayed. Historians consider it a minor, but

[1] *Atlas of Climatic Charts of the Oceans.* Government Printing Office. Washington, 1939.

possibly a deciding, factor. At all events, there was no reason for not expecting rain at Waterloo. As an average, it rains 17 days in June at Brussels nearby. Possibly the amount was above expectations.

In some regions there are strongly contrasted wet and dry seasons. This is one characteristic of the Mediterranean climate, with rain on about 10 days a month in winter and only on two or three days a month in summer. On the African side of the Mediterranean there is generally a rainless period of a month or more in summer. Jerusalem is rainless from June to September but has 12 rainy days a month in January and February. In some places in China and India the winter or northeast monsoon is practically rainless while the summer or southwest monsoon is very wet. Mexico City has a wet summer and a relatively dry winter; this is true also at many places on the west coasts of Mexico and Central America.

Examples of cities where the dry season is cool or cold are Tientsin, Mexico City and Vladivostok, while in other places the dry season is warm, as in Jerusalem, Los Angeles, Bombay, and Tunis.

Days with snow are shown in Table IV in the Appendix for the 110 places in Table I, but only those places are included which have had more than five days a year with snow, as an average. It should be kept in mind that in many places a day with snow is counted regardless of the amount, whether measurable or not, hence the number of days with snow may exceed the number of rainy days in Table III, which includes snow only if there is enough to measure when melted.

The foggiest regions of the oceans are in summer in the North Atlantic east of Newfoundland and in the North Pacific in the vicinity of the Kuril Islands. In general, there is more fog in the far northern and southern parts of the oceans than in middle and equatorial latitudes. There is very little fog in the tropics, the principal exception being the west coast of Peru. On the west coast of the United States, fog is prevalent in summer and autumn. Eureka, California, has fog on an average of 65 days a year, principally from July to November.

CHAPTER VII

SPECIAL PHENOMENA OVER THE OCEANS

MANY of the high spots of an ocean voyage—meteors and auroras in the heavens, phosphorescence on the sea, the sight of flying fish and porpoises—have little direct relation to weather conditions. There are some natural phenomena, however, that a fortunate traveler may encounter for which he is indebted to the weather alone.

Waterspouts, for example, are not rare. Many observant people who reside on the seacoast have seen one or more. And yet there are some sailors who have never seen one in a lifetime. When near, the waterspout (Fig. 31) is an impressive phenomenon, and to some extent dangerous; sailing ships have been dismasted and even a few have been capsized. In one spout which did not touch the vessel (a sailing ship) the crew had a critical experience. A waterspout was observed bearing down upon the ship. As it passed, "a terrific whirlwind took away the fore-topgallant mast, main and mizzen topmasts, and every stitch of canvas. One man went with the masts, and the master was blown around the poop like a piece of paper, and almost went overboard. Sky, and sea seemed one, resembling a smoking furnace."[1]

The waterspout, like the tornado over land, is a violent whirl in an updraught of air.

In reality, the waterspout, or that part which we see, is a cloud. Beginning usually as a vortex at the base of a cloud, it pushes downward in the form of a spout looking like the trunk of an elephant. Even before it reaches the sea, the surface of the water is greatly agitated below the spout. As the spout elongates it may

[1] Allingham, Wm. A. *A Manual of Marine Meteorology*. Charles Griffin & Co., Ltd. London, 1900.

Fig. 31. Waterspout.

be straight, slanted or curved. The cascade, or water disturbance at the base, increases in violence and a cone-shaped protuberance seems to rise and join with the descending spout. When the moisture in the spout condenses it is visible as a cloud; if not, the vertical motion is present anyway, as is evident by the agitation of the water. In extreme cases, a waterspout may be only a few hundred feet high or it may stretch nearly a mile from cloud to sea; the average is 1,000 to 2,000 feet.

It has often been said that a waterspout can be destroyed by firing a gun at it, but the average life of a waterspout is very short, perhaps fifteen minutes, hence it soon disappears anyway, leaving the gunner with the conviction that he has put it out of commission.

The spray that comes up from the sea is, of course, salty, while the moisture condensed in the spout is fresh, hence there have been contradictory reports as to the taste of the water in spouts that have been encountered by ships.

Mirage. The majority of us have had the experience of motoring over a highway in hot weather and seeing a pool of water which disappeared as the car approached. It was only the image of the sky. All kinds of mirage are caused by the bending of the rays of light on passing through layers of air of widely differing densities, which in turn are caused by temperature differences. A layer of warm, rarefied air near the ground may act as a mirror and reflect the sky, which appears as a pool of water.

Similar effects are the appearance of an inverted ship in the sky, or two ships, one inverted and the other erect. Spectral cities have been seen in the skies, being in reality the distorted images of buildings or other objects at a distance.

Deserts and polar coasts are especially favorable for mirage, but they may be seen almost anywhere when atmospheric conditions are favorable.

Halo and Corona. The "ring around the moon" (or the sun) may be a halo or a corona. The halo is formed in high clouds composed of particles of ice which bend the rays of light. In its more common form the halo (Fig. 16) has a radius of 22° but there may be

complex auxiliary features, including "mock suns" in the solar halo.

Lunar halos are better known to most people, for the solar halo must be observed usually with smoked or tinted glasses. If the halo is colored, the inside of the ring is red. The halo may be a very complex phenomenon; if we see an especially remarkable halo, we should immediately make a sketch of all of its parts. Afterwards, when we investigate it at our leisure, we may find that we have witnessed a rare phenomenon.

When fleecy clouds pass across the moon, a colored ring may be seen; it is of smaller radius than the halo and has the reddish color on the outside. It is caused by water droplets. This is a corona.

Nearly all of us have seen a corona. At night when the moon is shining and the clouds are broken, we see the clouds crossing in front of the moon; as we watch for a while it seems that the clouds are standing still and the moon is racing across the sky; and each time a fleecy cloud crosses the moon there is a small ring of color around it.

Crepuscular Rays. "Sun drawing water" is one of the familiar descriptions of crepuscular rays. The rays of the setting or rising sun illuminate the dust or haze in the atmosphere, while the clouds throw dark shadows. These alternate bands of light and shadow are really parallel; convergence toward the sun is only an effect of perspective. When the sun is below the horizon a little, the rays sometimes cross the reddish glow above the horizon, producing a beautiful effect of blue or gray, alternating with reddish, bands. When the sun is above the horizon and partially obscured by clouds, the rays may be seen extending downward to the horizon. Crepuscular rays present some strikingly beautiful effects at sunrise and sunset from the ship at sea (Fig. 47).

Green flash is a phenomenon of sunset or sunrise which may be especially well observed at sea, where the horizon is well defined. As the sun is sinking, so that only a narrow bit of the upper edge is visible and just about to disappear, its color changes to brilliant green, blending into blue. The green and blue rays are bent a little farther downward than the red and yellow rays and so are separated, as by a prism, the green and blue rays disappear-

ing last. At sunrise the process is reversed and the green and blue rays come first.

Rainbow. Everyone is familiar with the rainbow; it is especially beautiful at sea. The rainbow may have primary and secondary bows and in some cases there may be supernumerary bows, as in Figure 34. Rainbows are produced by a complicated process of refraction, reflection and interference of light on passing through raindrops. The observer, facing the rainbow, has the sun at his back and a sheet of falling rain in the foreground.

The radius of the primary is about 42°, hence the sun must be less than 42° above the horizon. The secondary bow has a radius of about 50°. Between the primary and secondary the sky appears darker than in the space inside the primary bow. The primary bow has red outside while the secondary has red inside.

Rainbows formed by the moon are faint but sometimes are clearly observed near the time of full moon.

At sea, bows may be seen in the spray of ocean waves, or indeed, in any place where water drops are thrown into the sunlight. A rainbow, colorless or nearly so, is formed in fog; it is called a fogbow.

Line Squall. A weather disturbance of the ordinary kind which brings us warmer, followed by cooler, winds, and alternating periods of rainy and clearing weather, often has a clearly defined shift line where the wind changes suddenly to a westerly direction with a sharp drop in temperature. Sometimes the wind shifts with a sudden shower and a squall. This marks the arrival of the "cold front," where cold air is underrunning and replacing the warm air; sometimes a roll cloud forms along the front. Owing to perspective the roll cloud appears to be shaped, as some sailors say, like a cigar. This phenomenon is not usually visible in the city or in hilly country but at sea the long roll of cloud, tapering to a point far away toward the horizon, is a sight to remember.

As the cold front and roll cloud approach and the cloud draws near, the wind may come out suddenly in a hard squall; a decided change in temperature is sure to follow.

When a cold wind blows out over a warm water surface, like

the Gulf Stream, fog forms in wreaths resembling smoke. The photographs (Figs. 32, 33) show a line-squall cloud in the Gulf of Mexico and a cold wind blowing on the Gulf Stream with fog wreaths.

St. Elmo's Fire or Corposants. Perhaps no description of weather at sea would be complete without some reference to the "fires of St. Elmo," also called "corposants." This phenomenon is simply a brush discharge of electricity from elevated objects, such as the masts and yardarms of ships, steeples, and lightning rods of churches and other buildings, usually observed in stormy weather. It is by no means confined to the sea; in fact, it is more common on mountain tops.

On sailing ships, especially, it is sometimes a weird and star-

FIG. 32. Line squall cloud. (B. A. Thompson)

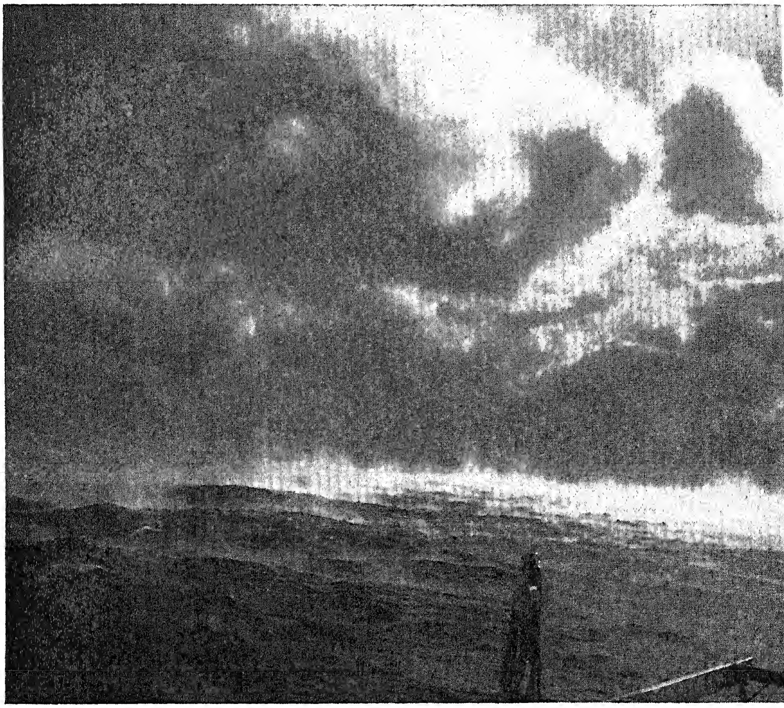


FIG. 33. Fog wreaths. (B. A. Thompson)

tling display, hence it has been most generally described in the accounts of navigators before the days of steamships.

The wireless aerial, masts, trucks, jackstays, and aerial insulators are mentioned in the accounts from steamships as the points where the displays are seen.

All the high projecting points become tipped with the glow or flames of electrical discharges, usually accompanied by a crackling or hissing sound. The hat and fingers of the observer may glow with the discharge but he suffers no inconvenience except a slight tingling sensation. One observer[2] on a steamship reported:

"During this time the vessel presented a remarkable appearance. On the truck of the foremast there was a flame about a foot and a

[2] Talman, C. F. *The Realm of the Air.* Indianapolis, 1925.

half high and a foot across and, from the truck to about thirty feet down the mast, balls of fire, half an inch to two and a half inches in diameter, were quickly running up and down the mast in a most agitated manner."

The differences of electrical potential between the atmosphere and objects on the surface of the earth are the causes of electrical discharges which are probably going on all of the time, usually with very slight intensity, but in stormy weather differences of potential are such that the discharges from elevated objects may become greatly exaggerated.

On a celebrated occasion the Prince of Wales (later King Edward) experienced the phenomenon of St. Elmo's fire on the

FIG. 34. Rainbow. (G. A. Clarke)

summit of the Puy-de-Dôme (France) on June 25, 1888. He took off his hat and his hair stood on end. When he lifted his arms above his head an electrical discharge took place through his finger-tips.[3]

The phenomenon of corposants has been recognized from antiquity. Caesar's soldiers were terrified when they saw flames dart from the tips of their pikes and swords. "In the month of February about the second watch of the night, a thick cloud suddenly arose followed by a shower of hail. The same night the points of the spears belonging to the Fifth Legion seemed to take fire."—*Caesar's Commentaries.*

[3] Mathias, E. *Traité d'Électricité Atmosphérique et Tellurique.* Paris, 1924.

CHAPTER VIII

EUROPE

It is time to take an actual trip or two. Suppose we begin with an ocean crossing from New York to Europe.

If it is winter, we are quite likely to have some rough weather, though it is true that modern steamships make a quick passage and possibly we may have nothing more than fresh to strong breezes. If it is summer, the chances are that we shall have a quiet passage, unless, as happens on rather rare occasions, a tropical storm comes up the coast from the West Indies and turns out into the steamer lane. We hope the weather will be fine, for sunshiny days are a great advantage on deck, while strong head winds and rain are serious inconveniences.

Perhaps the most noteworthy feature of the weather on leaving New York when it is either extremely hot or extremely cold in the city, is the great moderation of temperature after a few hours at sea. Everyone knows that when it is very hot in the city or country it is likely to be pleasantly cooler at the seashore. On the other hand, when it is very cold at a little distance inland, while it may not be appreciably warmer at the seashore itself, it does get warmer farther out. The cold air flows out over the sea but it does not go very far to sea without considerable moderation.

In New York City the highest temperature of record is 102°, the lowest of record 14° below zero. On July 9, 1936, the highest temperature of the day was 102°; at 8:00 p.m. of that day it was 96° but at the same time it was 66°—thirty degrees cooler—on shipboard at a distance of only 350 miles from New York. On February 9, 1934, it was 14° below zero in New York City but at the same time it was slightly above freezing on shipboard 350 miles to the eastward, or more than 46° warmer. Temperature near the freezing point is rare at that distance from shore.

In winter we expect cool weather at sea, but in summer when

Fig. 35. Stratocumulus. (A. C. Lapsley)

it is hot in the city we may be surprised at the coolness of the air over the North Atlantic. In northwestern Europe we may find it decidedly cool most of the time. The summer heat of mid-western United States is practically unknown in northwestern Europe.

On the route from New York to northern Europe the steamer lane goes north of east, and near the Grand Banks passes through a region where the cold Labrador Current extends southward against the Gulf Stream. The temperature contrast of these two currents is greatest in winter; the hydrographical contrasts in this area are the greatest in the world. At the boundary of the two streams in winter, a ship passing through the mixed water may encounter a change of temperature of more than 20° in a ship's length. In summer, the warm air from the southeast and south flows over this wedge of cold water and produces one of the foggiest regions of the world.

Icebergs drift southward in this region of cold water and formerly were a menace to navigation, but in more recent years the U.S. Coast Guard has maintained an ice patrol in the North Atlantic and in this way the presence of icebergs has been made known to shipping. This patrol service began after the sinking of the *Titanic* in 1912 and since that time there has been no repetition of the disaster.

The season of icebergs in this region is from March 15 to July 15. South of the Grand Banks they have occurred most frequently in May and June.

There is another feature of the weather over the North Atlantic that is worthy of note, especially in winter. The atmospheric disturbances which are sometimes attended by gales and rough seas, usually move from west to east, or southwest to northeast. Cloudy weather and rain commonly accompany these disturbances at all seasons, but they are more frequent and more vigorous in winter. Gales are largely confined to the cooler months. Since disturbances normally move in an easterly direction, the ship on an eastward voyage moves along with them.[1] If the ship is fast and the dis-

[1] This is true also of the other northern and southern oceans, but tropical disturbances when near the Equator move from east to west (Fig. 6).

turbance moves slowly, the ship may gain on it for a time and gradually leave it behind. Generally, however, the disturbance moves faster than the ship; the wind changes slowly and cloudy and rainy weather hangs on.

On the other hand, the ship may travel along in fine weather between disturbances. It is usual on an eastward voyage to experience a long duration of weather of a certain type which gives way very gradually to another type of weather. On a westward voyage the ship moves against the weather and the disturbances pass quickly with changeable weather.

Conditions on the North Atlantic routes are described in detail, month by month, in the Appendix.

Since the prevailing winds over the northern steamer routes are westerly and southwesterly, the ship on eastward voyages travels with the wind much of the time, hence frequently nothing stronger than a light wind is felt on deck even when there is a fresh to strong wind over the sea in the neighborhood. On westward voyages the movement of the ship is added to the movement of the prevailing winds and it is more frequently windy on deck. This is another reason why gales are more often experienced on westward voyages; strong winds come mostly from a westerly quarter and when the ship's movement is added to the wind, the result is a gale on deck, even though the ship's officers, looking at the sea, log the true wind as only a fresh breeze.

The westerly winds of the North Atlantic drive the warm waters of the Gulf Stream toward the coast of Europe. Going eastward from the Grand Banks, the temperatures gradually increase at all seasons. *In corresponding latitudes* the eastern North Atlantic Ocean and western Europe are decidedly warmer in winter than the western North Atlantic and the eastern coasts of North America. In the latter regions, the prevailing winds carry the cold outward from the interior of the continent in winter. London, for example, is much farther north than New York, but its mean temperature is 8° higher than New York in January. In summer there is not much difference in the temperatures in corresponding lati-

tudes on the east and west sides of the Atlantic, but European cities, especially in the north, seldom experience the extremely high temperatures that occur nearly every summer in eastern United States.

The British Isles are windy, especially on the western coasts. The weather is changeable and, since the prevailing wind comes from a relatively warm ocean, there is considerable humidity, cloudiness and rainfall at all seasons. There is generally more sunshine on the coasts than in the interior. Gloomy spots are the large manufacturing towns. London in December has an average of less than 15 minutes of sunshine each day. In summer there are spells of sunshiny weather but the air usually feels cool and damp to an American. We must be prepared for cooler weather and more rain and fog than we experience at home.

Tables in the Appendix include records for London, Plymouth, Brest and Amsterdam, which are sufficiently representative to show the character of the climates of all the nearby ports, Cherbourg, Cobh, Dover, Le Havre, Ostend, Calais, Southampton, Rotterdam and Antwerp.

At Glasgow (Table I) the average daily low temperature in summer is about 50°. Stockholm and Oslo are only slightly warmer. Night temperatures in summer there average about the same as at New York in October and at Galveston in midwinter.

Cool weather is common over much of northern Europe in summer. On the Continent at a little distance from the coast the days are slightly warmer and, together with the high humidity, may give an active person a feeling of oppressiveness on some occasions. The Continent in the north is subject to greater extremes of cold in winter than the northwestern coasts and the British Isles. On the whole, however, the temperature extremes of the British Isles and northwestern Europe, including Germany, Denmark, Holland, Belgium and France, winter and summer, are less severe than in northeastern United States.

On going eastward and southeastward into the interior of the Continent, the extremes become more severe until we come to Leningrad and Moscow with their bitter winters and to Bucharest

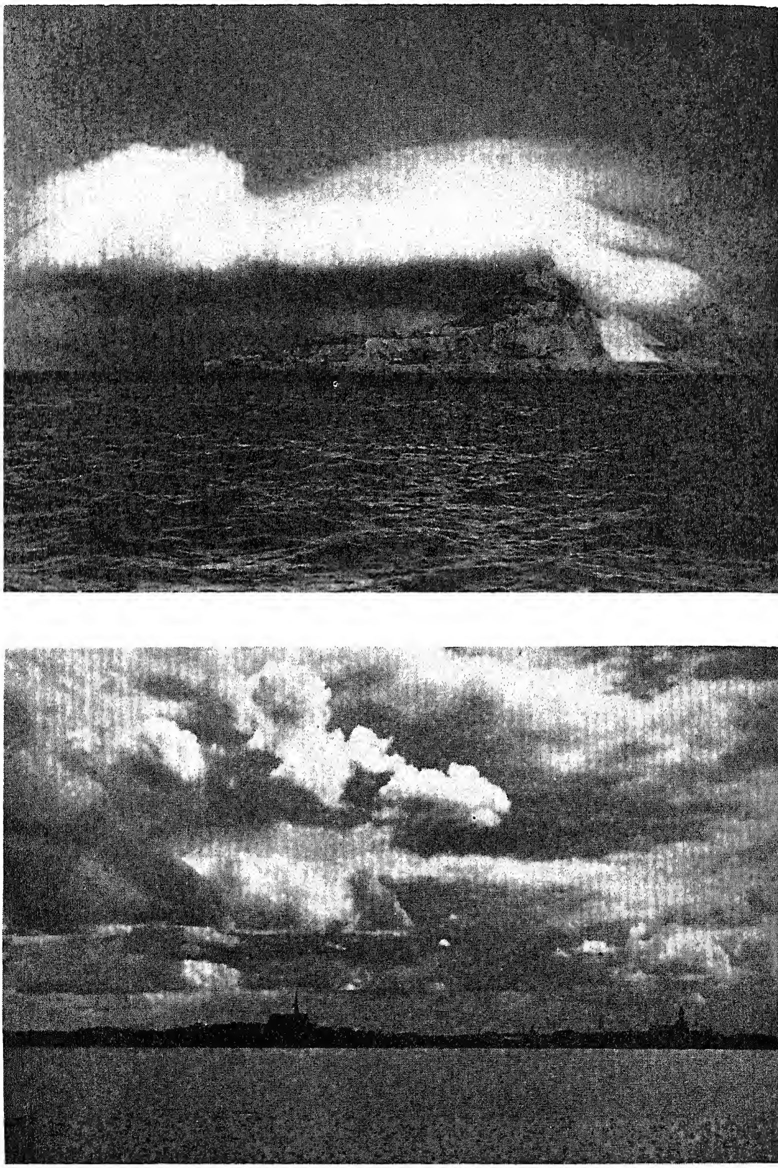


FIG. 36. Upper–Gibraltar with banner cloud (or "Levanter" cloud) which stretches out a mile or more from the rock when an east wind blows. Lower–Cumulus and altocumulus over Lake Vetter in Sweden, a lake noted for sudden storms.

on the southeast where the extremes of temperature, winter and summer, are much more severe than in New York City.

That it sometimes gets quite cold in winter in Denmark, northern Germany, Holland, Belgium and France, is evident from the records showing that temperatures on rather rare occasions have been below zero in Copenhagen, Hamburg, Brussels and Paris. Extremely cold air masses sometimes come from the east, draining out of the great pool of cold air in the interior of Russia and Siberia when the prevailing westerlies over Europe are absent and pressure is unusually high to the northeastward. That is probably what happened before the dramatic capture of the Dutch fleet by a handful of French cavalry in the winter of 1794-1795. The fleet was frozen in at the Texel and a small detachment of hussars rode out over the ice and browbeat the crews of the well-armed battleships into surrender.

It may seem astonishing, at first thought, that the lowest temperatures of record at Venice (14°), Madrid (10°) and Marseilles (11°) are not much higher than the lowest of record at London (9°). Since extremely cold air is a product of the interior of the continent, the Alps act as a barrier to its flow southward, while the North Sea and English Channel act almost as effectively in combination with the prevailing westerlies to prevent temperatures below zero in London. By comparison we have extreme low temperatures in central and eastern Europe as follows: Berlin –15°, Warsaw –28°, Moscow –44°. Russia, of course, has very cold winters, the warmest part at that season being in the southwest along the coasts of the Black Sea and the southern half of the Caspian Sea. In Siberia it is much colder; Verkhoyansk has a mean temperature of –58° in January, a record low of –94°, and the *highest ever recorded* there in January was –13°!

It is a queer fact that in some of the very cold spots, the cold air accumulates in the valleys where the weather-recording stations are located but the higher lands are generally thought to be warmer—a sort of upside down climate. In eastern Turkestan, the low lands have spells of cold weather in winter when the tempera-

ture sometimes falls below zero. The inhabitants then seek warmer weather by going up into the mountains.

The vast battlefront in Russia in the winter of 1941-1942 brought vividly to the minds of hundreds of millions of people the intense cold in many Russian cities, but to a large extent it has left an exaggerated impression of winter in European Russia. The average temperature at Moscow in January is 9°, the same as at Bismarck, North Dakota, while Leningrad averages 18° in January. Stalingrad (about 15° in January) is not as cold as Duluth (10°) or St. Paul (12°), and we have to go into Siberia before we find winters as cold as in northern Canada.

European Russia is not as hot in summer as our Middle West. The averages in July are 71° at Moscow, 73° at Odessa, and 77° at Astrakhan; while Omaha is 77°, St. Louis 79°, and Little Rock 80°. We have to go into Asia or Africa to find midsummer temperatures averaging as high as in Texas.

In the southern parts of Greece, Italy and Spain, summer and winter temperatures average about the same as in South Carolina, but these parts of southern Europe do not have the extreme low winter temperatures that occasionally occur in South Carolina.

In the extreme north of Europe temperatures are considerably lower. The southern parts of Norway and Sweden have roughly the same average summer temperatures as northern Maine, and winters as cold as Boston. The west coast of Norway is not subject to such extremes as in New England. The lowest temperature of record, 7° above zero at Bergen, may be compared with records of –22° at Stockholm, –13° at Oslo, and far below zero in practically all of New England. In the mountains of Norway and Sweden it is much colder. Snow falls in July at higher elevations. However, Norway and Sweden are farther north than Labrador. They lie in about the same latitude as Greenland. Summer days are very long; at Bergen midnight in June and July is almost as bright as noon on a cloudy day in Chicago in December. Farther north the sun never sets in midsummer. Nights are correspondingly long in winter and, of course, the sun does not rise above

the horizon at noon in northern Norway and Sweden in midwinter; this country is as far north as northern Alaska.

Farther to the north is Spitzbergen, where the climate is not nearly so cold as would be expected at that latitude (78°N) which is far north of the northern tip of Alaska. The average July temperature at Spitzbergen is 42°. February is the coldest month, with an average of 2° below zero. Occasionally, however, owing to the proximity of extreme cold in Siberia, it is very cold in Spitzbergen, where the low record is –57°.

At high elevations in the Alps it is very cold. Sonnblick in Austria is near Brenner Pass where Hitler and Mussolini met. There is an observing station at a height of 10,200 feet which has an average temperature of 34° in July and 8° in February. At elevations near 5,000 feet in Switzerland the average ranges from about 20° in January to about 55° in July.

The Caucasus at high elevations has the usual mountain climate, but is not quite so cold at the same elevations as the Austrian Alps. Kars, in extreme northeast Turkey near the Russian Caucasus, is 5,720 feet high. The temperature averages 10° in January and 64° in August.

The effectiveness of the Alps as a climatic barrier across southern Europe is reflected in the history of the old Roman Empire. There are many passes through which the armies of early times struggled, mainly in the warmer half of the year. The Carthaginian army crossed Spain and the western Alps, emerging in the Po Valley, but the African troops, unaccustomed to the vigorous climate of the Alps, suffered losses of 10 to 20 per cent.

CHAPTER IX

WEST INDIES AND SOUTH AMERICA

IF WE draw a line due south from Detroit, Michigan, all of South America will be *east* of that line. Rio de Janeiro is about 2,000 miles farther east than New York, and Natal, at the eastern tip of South America, is nearly 2,500 miles farther east. If our ship leaves New York and heads directly for the Cape of Good Hope, South Africa, or for Rio de Janeiro or Buenos Aires, we go southeastward and are soon well out in the Atlantic.

If it is winter it is likely to be cold in the harbor. If our destination is in the West Indies or South America we run into warm weather two or three days later. Our northern winter comes at summertime in the Southern Hemisphere, so it will be decidedly warm from the West Indies nearly to the southern tip of South America.

As we go southward we experience increasing sunshine and diminishing storminess. At about the latitude of Nassau the ship comes into the trade winds. They blow mainly from the northeast in winter and from the east in summer. From the standpoint of climate, the trade wind belts are the most delightful regions of the oceans.

The West Indies

The West Indies are pleasantly warm in winter and not too warm in summer. Cold waves of the North American continent seldom reach to the West Indies, even in a mild form, and when an exceptionally severe wave extends well out over the Atlantic or Gulf it has no appreciable effects beyond the Bahamas and Cuba. At San Juan the lowest temperature of record is 62°; at Barbados the lowest was 61°.

The cold wave of February 1899 is generally considered the most severe in the history of the United States. In New York there

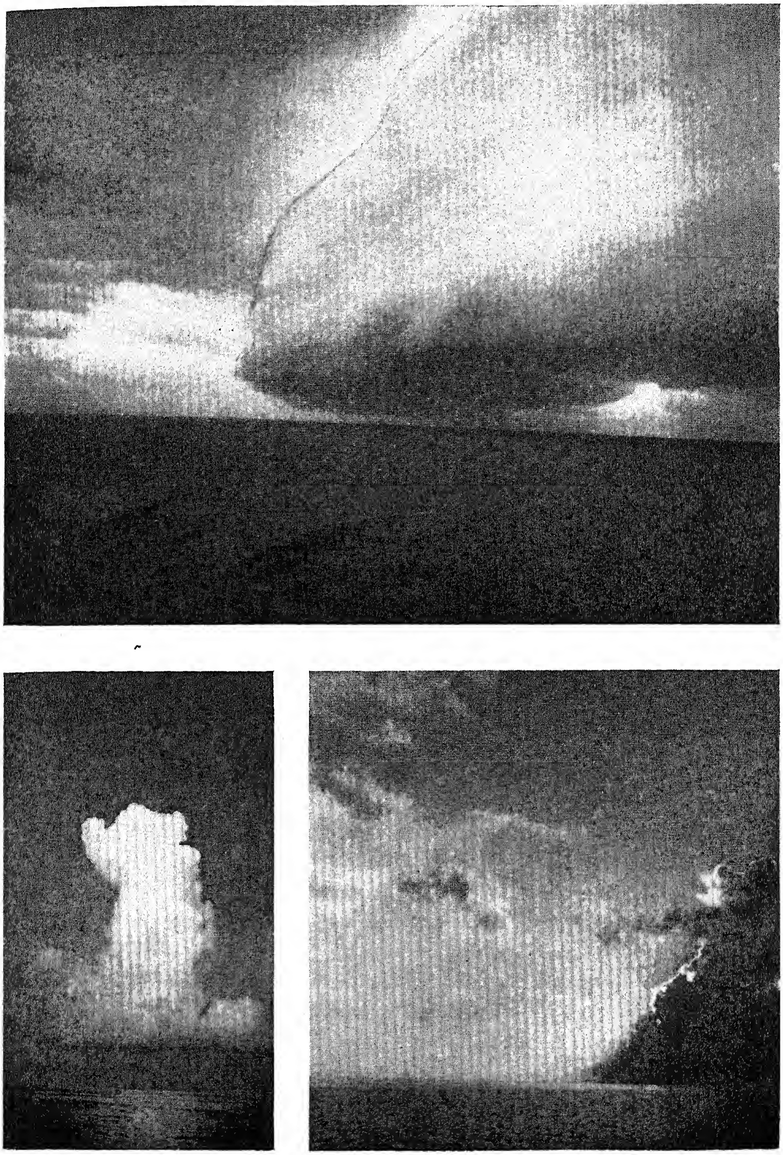


FIG. 37. Above, the "cold front" of a Texas "norther" pushing out over the Gulf of Mexico; lower left, a flat-bottomed cloud of the cumulus family; lower right, clouds like mountains rise from the sea—cumulonimbus with a heavy curtain of rain between cloud base and sea. (B. A. Thompson)

was a blinding snow storm which, in conjunction with vast fields of moving ice, closed New York Bay and brought ocean traffic to a full stop. After the storm there was indescribable confusion in New York City, where traffic was confined to a narrow space covered by car tracks with snow piled eight feet deep on either side. Zero temperatures were recorded to the Gulf Coast of Alabama. At Miami the temperature fell to 29°. Northerly winds reached to Panama, and there were high seas on the evening of the 13th on the Caribbean side of the Isthmus. Northerly gales reached Havana, and there was much damage along the northern coast of Cuba. Water and waves were the highest known there in twenty-five years. A number of houses were washed away and many others damaged. The temperature at Havana fell to 54°. Even under these extraordinary conditions, there was very little effect at San Juan and almost none at Jamaica or in the remainder of the West Indies.

Owing to the large number of ships stopping at Bermuda and Nassau, or traveling in that area, weather conditions along this route are presented in some detail.

On the steamer lane from New York to Bermuda and on the route to Nassau as far as Cape Hatteras, there are occasional fresh to strong gales in the cooler half of the year, although stormy weather is not nearly so frequent there as on the northern routes to Europe. The relative frequency of gales in this area is shown in the table which follows. Numbers in the table represent the probability of winds of Force 7[1] and higher on the Beaufort Scale. The number 12, for example, indicates that the wind is Force 7 or higher, as an average, 12 per cent of the time. Winds of Force 8 are infrequent in this area, hence moderate gales (Force 7) are included in the tabulation on page 85.

An inspection of the table shows that stormy weather is infrequent near Nassau and that summer is the most favorable time in the northern part of the area. However, it must not be assumed

[1] For the frequency of gales of Force 8 or higher, see Figures 5 and 6.
[2] For scale of wind force see page 8.

TABLE OF STORMINESS*

	New York to Bermuda			Bermuda to Nassau			New York to Nassau		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
January	12	22	18	16	10	5	12	15	6
February	13	25	18	16	10	5	13	17	6
March	13	20	14	12	9	4	13	14	6
April	7	15	10	7	5	2	7	9	3
May	3	6	2	2	2	1	3	4	2
June	2	5	2	2	1	1	2	3	1
July	1	3	1	1	1	1	1	2	1
August	2	4	2	2	1	1	2	2	2
September	3	6	4	4	3	2	3	4	3
October	8	13	6	6	5	4	8	8	5
November	12	18	10	10	7	4	12	10	5
December	12	22	12	11	8	4	12	12	5

* The first part of the route, in each case, is numbered (1), the middle part (2), the final third of the route (3). On the New York-Bermuda route, the column numbered (1) shows percentage of gales in the first third of the route outward from New York; column (2) shows gale frequency in the middle of the route; column (3) in the waters near Bermuda toward the end of the route. Likewise, the other two columns numbered (1) show gale frequency in waters outward from Bermuda and New York, respectively; columns (2) in the middle of the routes; columns (3) in the final third of the routes from Bermuda and New York, respectively, as the ship approaches Nassau.

that the sea is always smooth when there are no gales in the area. Swells originating in the storms of northern waters, especially in winter, are often felt in the region between New York and Bermuda and southward beyond Cape Hatteras. When the weather is quiet locally, long low undulations from distant storms are nearly always present in some degree in the cooler half of the year and to some extent, but much less noticeably, in summer.

The greatest frequency of rain is found in the middle of the route, New York to Bermuda, in winter 15 per cent, in summer 10 per cent. Toward Nassau the probability of rain is only 5 to 10 per cent in winter and about 5 per cent in summer. Cloudiness is greatest over the whole area in winter, 60 to 70 per cent from New

York to Bermuda and only 40 to 50 per cent near Nassau. There is an abundance of sunshine over the whole area in summer, cloudiness being only 40 to 50 per cent. Dense fog is met about 12 per cent of the time in waters near New York in spring and summer and only 3 to 5 per cent in autumn and winter. Over the remainder of the area, fog is not common.

Average temperature of the air over the ocean on the routes from New York to Bermuda, New York to Nassau, and Bermuda to Nassau, are given in the accompanying table. In each case there are two numbers separated by a hyphen; the first is the average temperature experienced at sea after the ship leaves the first named place and the second is the average temperature at sea on approaching the last named place. For example, on the New York to Bermuda route in January the numbers 53-64 indicate that the air temperature is 53° over waters outside New York and it rises gradually to 64° over waters near Bermuda.

	New York to Bermuda	*New York to Nassau*	*Bermuda to Nassau*
January	53-64	50-70	66-70
February	51-63	46-70	64-70
March	53-64	50-71	64-70
April	57-66	55-74	66-72
May	64-71	62-78	71-75
June	71-76	69-80	76-79
July	76-80	75-82	80-82
August	76-81	76-82	81-82
September	74-79	72-81	79-81
October	68-75	65-78	75-78
November	60-70	57-74	70-74
December	56-66	51-71	66-72

If we go from Boston to Bermuda we are not likely to experience any appreciable difference in the weather from that which prevails on the route from New York. If we go from Norfolk we shall find it a little warmer near the coast, especially in winter. Data for New York and Norfolk may be compared in the Appendix. As a rule, the route from Norfolk is less stormy; the frequency of

winds exceeding Force 6 is almost one-third less on the outward voyage from Norfolk than on the first part of the route from New York.

On account of the small variation of temperature between winter and summer in the West Indies, the seasons are known as dry and wet, not hot and cold. The mean temperature at San Juan varies from 80° in July to 75° in January; at Barbados it ranges from 80° to 76°. At Havana the variation is a little larger, owing to its nearness to the continent, but even there the variation is only 10°, from 82° in August to 72° in January and February.

As a rule, the warmer part of the year is the wet season and the cooler part is the dry season. On the higher islands, the slopes of the mountains which face into the prevailing easterly and northeasterly winds are wet and the slopes away from the wind are dry. Elevated lands are cooler.

Because of the decrease of temperature with elevation, some cities, which are near the sea in the tropics, have lower temperatures than would otherwise be expected. In such cases, the port at sea level may be considerably warmer. An example is Caracas, Venezuela, at an elevation of 3,500 feet with a mean annual temperature of 67°, whereas La Guaira, at sea level nearby, is hot with a mean annual temperature of 81°.

In Central America, the city of Guatemala (4,800 feet) has a mean annual temperature of 65°; San Jose, Costa Rica (3,700 feet), has a mean annual temperature of 68°; at San Salvador (2,250 feet) it is 74°. All have quite similar climates in other respects. Rainfall is frequent in late spring, summer and early autumn but with a short dry season in July or August and a long dry season in late winter or early spring. Table I in the Appendix gives average temperatures at San Salvador; averages at San Jose are about 6° lower and at Guatemala about 9° lower. Belize, on the Caribbean coast, at sea level, has a mean annual temperature of 79°, with monthly values very nearly the same as Kingston, Jamaica (Table I). Vera Cruz, also at sea level, has monthly and

annual temperatures almost the same as Havana (Table I). Mexico City is cooler.

Tables in the Appendix include records for San Juan and Barbados which are representative of temperatures in port cities of Haiti, the Virgin Islands, Dominica, Guadeloupe, Martinique, Trinidad, Curaçao, and other islands in that region. Curaçao, however, has less rain than the other islands to the eastward and northeastward.

The principal hurricane months are August, September and October. However, the whole region averages only about seven in a year; only a limited part of the area is affected by any single storm; they progress at a rate of about 12 miles an hour, as an average, and are seldom felt at any one place for more than a day or two. For these reasons the chance of meeting one on any single voyage is very small.

At times in years gone by, hurricanes have been very destructive to shipping and to property on the islands. One of the most severe was called the "Great Hurricane." It occurred in October 1780 when the British and French were at war. Ordinarily both fleets withdrew from the West Indies in the hurricane season except for relatively small forces, but they were badly hit by this hurricane. It swept across the Caribbean Sea from Barbados toward Puerto Rico. An English fleet off St. Lucia was completely destroyed. Near Martinique the hurricane enveloped a convoy of French transports and sank more than 40 ships carrying 4,000 soldiers. The islands in its broad path were devastated.

There have been hundreds of severe hurricanes since that time but in recent years they have caused the loss of very few ships in the West Indies, owing partly to warnings by radio and partly to better knowledge of the nature of hurricanes.

Through the Tropics

If we go through the Caribbean Sea to South America by the Panama Canal, we begin to feel the true tropical climate. The eastern extremity of the Pacific belt of doldrums is very near or

over the Isthmus, depending on the time of year. Every month is more or less rainy, but the months from May to December are the wettest. The temperature is remarkable for its uniformity. The coolest month, if we may use that expression for a hot climate, is only a degree or two below the warmest. The percentage of cloudiness is high, averaging about 75 per cent in the rainy season. The weather is usually better in late winter and early spring when the doldrum belt moves to the southward and trade wind conditions extend to the Isthmus. However, real extremes of temperature are never felt; the highest of record at Cristobal is 93° and the lowest 66°. But the humidity is high and we shall feel much better when we arrive in the trade winds along the western coast of South America.

Between the Canal Zone and the Equator conditions do not improve materially, in fact during the late winter and early spring of the northern hemisphere the weather is more sultry and oppressive between the Canal and the Equator than on the Isthmus.

As the ship moves through the muggy air from Panama toward the Equator, under overcast skies, we would scarcely suspect, unless forewarned, that a desert lies ahead. The vegetation on shore is tropical; the slopes are heavily wooded. Just 3° or 4° below the Equator the scene suddenly changes. The hills become bare and the desert reaches down to the coast. The rainfall chart, Fig. 30, shows this transition from the strip of frequent rains just north of the Equator to the dry region along the coast of Peru.

The cold Humboldt Current (Fig. 26) flows northward along the west coast of South America nearly to the Equator where the main body of the current turns northwestward into the Pacific. In all latitudes it is colder than the air above it; its effects are most marked along the northern coast of Chile and on the coast of Peru. This chilling current effectively diminishes or eliminates the rainfall. Instead of the heavy cumulus clouds of the tropics there is now a low, gray sheet of cloud, frequently threatening rain but seldom producing any. In some places on the coast of Peru the annual rainfall averages less than half an inch, compared with the 100 inches that fall in many equatorial regions. The cloud

sheet over this current is shown in the black space on the chart in Figure 29.

Although the humidity continues high the cooler air is a relief. Southward, along the coast of Chile, the rainfall gradually increases until we come to the region of very heavy rains south of Valparaiso.

In summer it is dry at Valparaiso; the strong sea breezes are an outstanding feature of the climate. In winter it is wet and the hills change from brown to green. All along this coast north of Valparaiso the desert does not extend far inland. The mountains being near to the shore, we need take only a short excursion to the interior to find increasing rainfall with elevation. At Lima in winter it rains nearly every day but it is only a fine drizzle or mist and the total amount is very small. However, we must keep in mind that winter of the southern hemisphere is summer of the northern and hence the winter mists of Lima come in June, July and August as do the rains of Valparaiso.

The variation of temperature along the west coast of South America, summer and winter, is indicated by the records in the Appendix for Lima, Valparaiso and Punta Arenas.

Callao, the port of Lima, is warmer than Lima in the southern winter and not quite so warm in summer. Valparaiso, likewise, is warmer than Santiago in the southern winter and cooler in summer.

Going southward from Valparaiso the prevailing winds become southwesterly and then westerly; gales become more frequent and below the southern tip of the continent the wind is of gale force nearly a fourth of the time in winter. An endless stream of weather disturbances moves from west to east in the region south of 50° south latitude, causing the wind to shift from southwest to northwest and back again as each new disturbance passes. These winds are the prevailing westerlies but they are so strongly developed in the southern hemisphere that they are called the "Roaring Forties" (Fig. 6).

The weather in this region is generally unpleasant. At Punta Arenas the mean temperature of the warm season is about 50°;

in the cold season it is below 40°. No extremely low temperatures are known in that latitude, as the continent is too narrow in the south to produce any severe cold waves. But the temperature at Punta Arenas has been down to 11° in June and below freezing in every month of the summer (December to February).

Travelers avoid the boisterous weather of the extreme south by going overland from Valparaiso to Buenos Aires; on this journey, which takes us over the Andes, a great diversity of climates may be experienced. Data for interior cities of South America are given in Table V of the Appendix.

East Coast of South America

Northward from Cape Horn to Buenos Aires on the eastern side, the winds diminish in force, and cloudiness and rainfall are, as a rule, less in corresponding latitudes than on the west coast. At Buenos Aires the climate in summer (December to February) is favorable. The nights are cool, the days warm, and there is not a great deal of rainfall. The winters are cool but not more severe than on the Gulf Coast of the United States, and the extreme temperatures have not been so low as at New Orleans and Galveston. Here, as elsewhere in the Southern Hemisphere, the winds are reversed, that is, northerly winds are warm and moist and southerly winds cool and more often accompanied by clear skies, just the opposite of conditions in the Northern Hemisphere.

Northward from Buenos Aires it becomes progressively warmer with more frequent rain until the mouth of the Amazon is reached. At Para it rains nearly every day in the first part of the year and on more than half of the days in the "dry" season. From there until we arrive in the West Indies the weather is generally hot and humid with frequent showers; the doldrum belt is encountered just north of the Equator.

Tables in the Appendix include data for Buenos Aires, Rio de Janeiro, Pernambuco (Recife), Para, and Georgetown which show climatic conditions along the coast. Georgetown, in British Guiana, is representative of conditions at Cayenne and Paramaribo. The rainfall régime changes between Pernambuco and Rio de Janeiro.

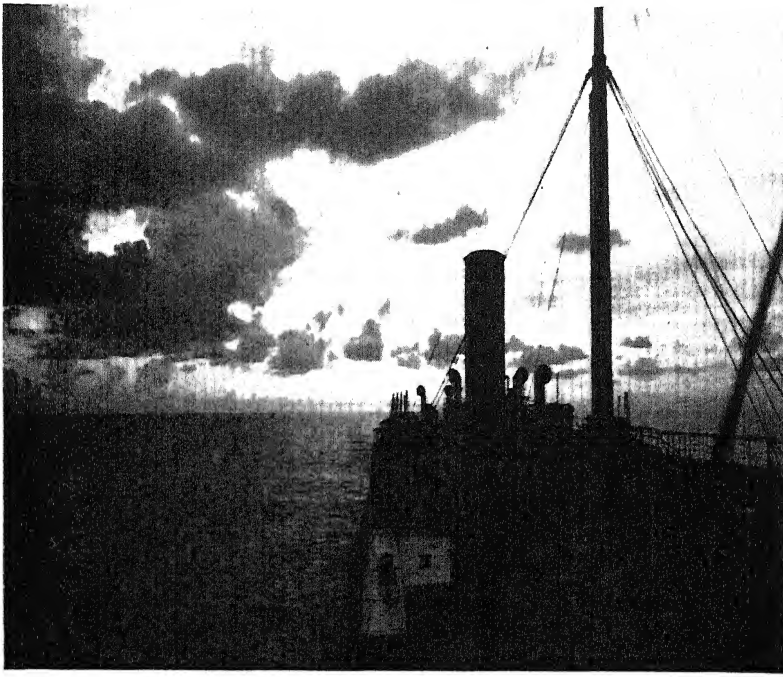


FIG. 38. A peaceful scene at sunset in the Gulf of Mexico. (B. A. Thompson)

The former has more rain in the southern winter, the latter has more in summer. Bahia (Saõ Salvador), which lies between, has a fairly even distribution throughout the year. Farther south, the climate of Montevideo does not differ much from that at Buenos Aires, but Montevideo has good breezes from the river in the afternoons and evenings in summer, and its beaches are visited by many tourists.

The Interior

The interior of South America has a great variety of climates. All of the northern part east of the Andes is tropical. It has more rain than any other region of the same size in the world. It is believed that much of the vast upper Amazon Valley has an annual average of more than 100 inches. It is uniformly hot throughout the year as shown by the records for Manaos in Table V of the

Appendix. The region around Manaos and the lower valley has 60 to 100 inches a year. Southward to southern Brazil the climate is generally hot with plenty of rain, but the extreme southern part is cooler in the southern winter.

The Guianas are hot and wet. Venezuela is rather dry considering its tropical location; this has never been satisfactorily explained, but it has been suggested that Caribbean waters are relatively cool off the coast of Venezuela. It is cooler at higher elevations as shown by the records for Caracas in the Appendix. The Dutch West Indies are also relatively dry. Colombia and Ecuador are hot in the lowlands, but there is the usual decrease of temperature with elevation in the mountains. In Bogota it is uniformly cool all year with an average temperature of 58°, about like summer temperature in San Francisco.

FIG. 39. A stormy scene at sunset in the Gulf of Mexico. The clouds in Figure 38 were moving very slowly; in the picture above the clouds were moving rapidly, with a hurricane in the vicinity. (B. A. Thompson)

Bolivia has every sort of climate from tropical lowlands to extreme cold of the snow-covered Andes. At La Paz (12,000 feet) the average temperature ranges from 44° in June to 52° in December. Above 18,000 feet there is snow and an Arctic climate. The Lake Titicaca basin at an elevation of about 12,000 feet is densely populated. This basin is about 80 miles broad and 500 miles long.

Paraguay has a mean temperature of about 65° in winter (June, July, August) and 80° in summer (December, January, February). South winds are cool and dry, north winds hot and moist. There is plenty of rain. Uruguay has a fine climate, with temperature ranging from 50° in July to 71° in January, much like San Diego temperatures in reverse.

Except in the mountains, the temperatures in the interior of Argentina show a gradual transition from the warm summers and cool winters of the north to the bleak cold of winter and cool summers of the extreme south. Salta in the extreme north (about 3,900 feet) has means of 72° in January and 52° in July, with dry summers and wet winters. In the south, Sarmiento (in Appendix) has 65° in January and 38° in July, with light rain throughout the year. Records for Asuncion in Paraguay, near the Argentine border, and for Cordoba are also given in the Appendix. Other records for the interior of South America in Table V are for Bogota, Manaos and La Paz.

CHAPTER X

THE MEDITERRANEAN AND THE MIDDLE EAST

On going direct to the Mediterranean from an Atlantic or Gulf port of the United States, we are likely to have warmer weather with less storminess than on northern routes. In the colder months these advantages are important. Also, there is usually more sunshine, especially over the eastern Atlantic where the ship passes along the northern border of the northeast trades into the Mediterranean.

Its sunshine has made the Mediterranean famous. Even in winter, which is the season of most frequent rains, cloudiness is not excessive. This applies to Spain and other countries in southern Europe except the higher lands of the Balkans and northern Italy. In parts of northern Africa, bordering the Mediterranean, there is less cloudiness than on northern shores.

July and August are the hottest months. The shores of the eastern Mediterranean are warmer than the western, especially on the African side. Over most of the Mediterranean region, the most favorable temperatures are found in late May or early June and again in late September or early October. There is somewhat more cloudiness and rainfall during these periods than in midsummer with its abundance of sunshine, but midsummer temperatures are sometimes a little too high. However, the entire period from May to October is generally favorable.

In winter, the Mediterranean region is moderately cold. The southern shores have temperatures averaging about the same as the Texas coast in winter, but without cold spells as severe as those occasionally felt on the Gulf coast. The northern shores are colder than the Gulf coast in winter.

Strong winds are not common on the Mediterranean; they are

FIG. 40. Cumulonimbus. (C. E. Deppermann)

usually of a local or regional character when they do occur. In some parts of the northern Mediterranean, cold winds frequently blow down the valleys from the mountains and out over the sea. At Marseilles, cold winds with the name "mistral" prevail on more than one hundred days a year, chiefly in winter. The "bora" of the Balkan Peninsula and the Adriatic is a similar wind.

Perhaps the best known wind of Europe is the "foehn," which corresponds to the "chinook" of the Rocky Mountains. These are cyclonic winds which become warm and dry by compression while descending on the lee side of a mountain range. When the foehn wind sets in, the temperature rises very rapidly; if there is a snow cover, it evaporates so quickly that it seems to disappear by magic; everything becomes so dry that precautions against fire are sometimes necessary to prevent a general conflagration. The foehn occurs principally on the northern slopes of the Alps but occasionally on the southern side. In some valleys it is felt on thirty to fifty days a year. In the United States a wind of this type is particularly common in Wyoming and Montana. In the Northern Hemisphere it occurs principally during the cold season from November to March.

In Italy, Malta and Sicily, southerly winds called the "sirocco" are occasionally felt in winter; they come from Africa and are hot and dry but accumulate moisture in crossing the Mediterranean and on reaching Italy are damp, accompanied by clouds and rain. However, dry, dusty and hot southerly winds may occur in any month in Sicily and southern Italy but they are most frequent in spring. On the African coast and in Syria and Arabia, winds of this character, called "simooms," are dreaded because of the dust and intense heat, which may even rise above 120°. They occur mainly between May and September.

There are many other special names for winds in the regions bordering the Mediterranean. There is the *Harmattan*, which is a very dry wind prevalent in western Africa, sometimes called *The Doctor*; *Khamsin*, a hot, dry southerly wind over Egypt; *Leste*, a hot, dry wind in Madeira and northern Africa; *Levanter*, a strong wind from the northeast on the east coast of Spain or an

east wind at Gibraltar (Fig. 36); *Leveche*, a hot, dry southwesterly wind in Spain; *Solano*, a hot, dusty, moist wind from the east and southeast on the east coast of Spain and in the Straits of Gibraltar; and *Vendavales*, southwesterly winds in the Straits of Gibraltar.

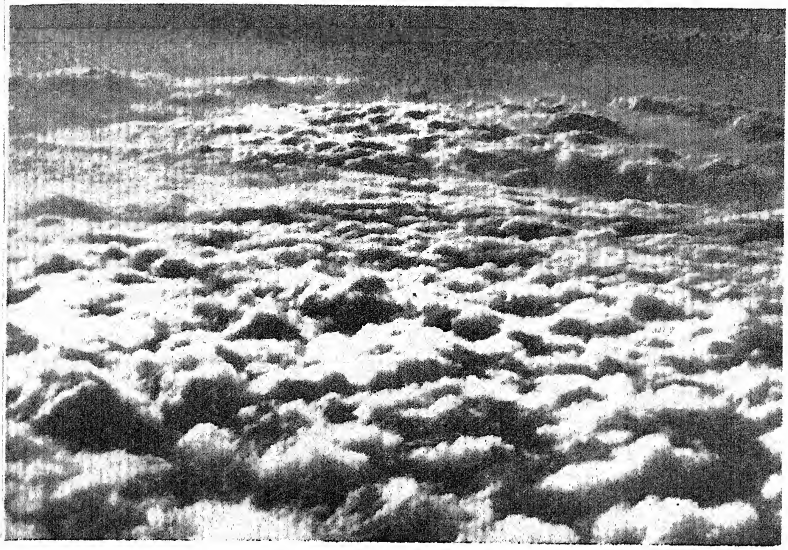
Northern Africa

That part of Tunisia, Algeria and Morocco bordering on the Mediterranean, is in a latitude about the same as that of southern California, and in many respects the climate is quite similar. Along the coast both have cool rainy winters and warm day summers. Both have mountainous areas close to the sea. Morocco has the cool Canary Current of the Atlantic along its western border corresponding to the cool California Current.

January temperatures along these Mediterranean shores average from 50° to 55°; along the Atlantic from 55° to 65°, while in midsummer the Mediterranean coast in this section averages 75° to 80° and on the Atlantic side 72° to 76°. These temperatures may be compared with 56° in January and 72° in July at Los Angeles. The yearly rainfall is 16 inches at Tripoli and Tunis, 14 at Mogador and 16 at Casablanca; Los Angeles has 15 inches. Los Angeles, like the coasts of Tunis, Algeria, and Morocco, has nearly all its rain in the cooler half of the year, mostly in midwinter.

Except at high elevations in the Atlas Mountains bordering these coasts, the extremes of summer temperature become more pronounced toward the desert interior. At Fez the temperatures range from 50° in January to 82° in August. At Biskra in the interior of eastern Algeria, the range is from 53° in January to 92° in July. At In Salah, farther in the interior, the averages are 55° in January and 99° in July.

The western slopes of the mountains have more rain than the Atlantic coast. Taza, for example, has about 25 inches; Fez has 21 inches. Along the coast between Algiers and Tunis, where the mountains are near the coast and are swept by the Mediterranean winds, we find the wettest part of this area, with 30 to 40 inches, mostly in winter. Bougie has about 40 inches. Snow falls occasionally in winter in the mountains above 3,000 feet. The higher moun-



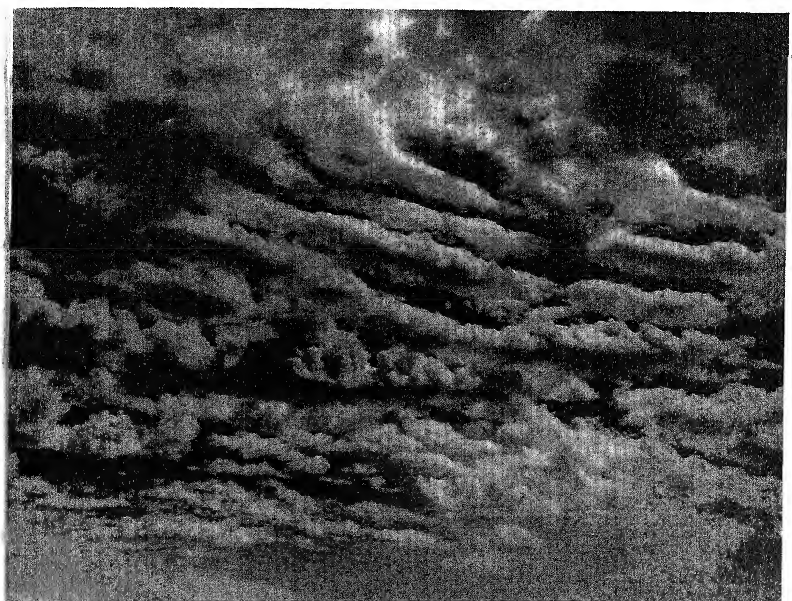


Fig. 41. Upper–Looking down from an airplane on altocumulus clouds over France. (C. K. M. Douglas). Lower–Altocumulus from below. (H. T. Floreen)

tains are snow-covered except in midsummer but on the highest peaks (about 14,000 feet) there is perpetual snow. The plateaus are hot in summer and often bitterly cold in winter. There is light rain in summer; somewhat more in winter and a maximum in spring. At Geryville (4,280 feet) the average January temperature is 38° and a low of 16° has been recorded.

From Tripoli eastward, the desert reaches almost or quite to the coast. The rainfall at Tripoli is 16 inches a year, Benghazi 11 inches, Port Said 3 inches. All of the interior is a part of the great Sahara Desert. It has the hottest summers on earth. The range of temperature in the heart of the desert is 50° or more in summer. Extreme ranges of 55° to 68° have been observed in one day. In July all of the central Sahara has a mean temperature above 95°. In large parts of the Sahara there is no rain for years at a time.

Egypt has a little rain in winter along the immediate coast. At Cairo the annual fall averages one inch. South of Khartoum there is more rain, but it falls mostly in summer, in contrast to the winter rains of the Mediterranean coast.

The Hottest Place in the World

It is said that the Red Sea, in the warmer part of the year (June to September) is the hottest region in the world. Certainly the combination of high temperatures and humidity (records for Jidda are given in the Appendix) is very oppressive. As far as *average annual* temperatures are concerned, Massawa in the south on the African side of the Red Sea is shown by instrumental records to be actually the hottest place in the world. The *average annual* temperature of Massawa is 86½°. However, other places are hotter in midsummer. Greenland Ranch in Death Valley, California, has a July average temperature of 101° and a recorded extreme of 134°.[1]

The Meteorological Office in London found from an examina-

[1] A higher temperature, 136°, claimed to be the highest reliable temperature ever recorded, was reported from Azizia which is 25 miles south of Tripoli in northern Africa. However, there is some doubt as to the accuracy of the observations at Azizia.

tion of ships' weather observations that the highest air temperature recorded on a ship under way was 100° in the Red Sea.[2] Incidentally, the highest temperature of the water surface recorded on a ship in motion was 96° in the Persian Gulf. The lowest air temperature noted by a ship under way was 40° below zero, recorded near the northern coast of Alaska on a steamship beset by ice off Sea Horne Reef.

In winter months, temperatures in the Red Sea region are not so high as in summer, the difference between seasons being greatest in the north. At Aden, January is the coolest month, 76½°, while at Cairo the temperature in winter is now and then below 40°.

Cairo is slightly warmer in summer and cooler in winter than are Port Said and Alexandria. The latter places, particularly Alexandria, have a little more rain in winter than Cairo. In general, however, the data in the Appendix for Cairo are representative of conditions at Alexandria and Port Said.

A very disagreeable experience in this region is a duststorm. Along the shores of the Red Sea there are local storms carrying enormous amounts of dust which are known as "haboobs." Masses of dust and sand several thousand feet high on a front ten to twenty miles in width sweep along at a speed of 30 miles an hour. The "zoboa" is a whirlwind pillar of sand which moves along with great velocity. The "Khamsin" is a dry southerly wind of spring carrying dust and sand that forms a thick yellow haze. During the summer monsoon in the Gulf of Aden and in the western Arabian Sea, the winds are very strong from the southwest, frequently with gale strength, blowing into the great cyclone over the heated lands of Asia (Fig. 6). These winds carry vast quantities of dust over the ocean from Arabia and Somaliland.

Southwestern Asia

Most of Arabia is desert. It is one of the hot regions of the earth. The high humidity along the Red Sea (Jidda records are

[2] Hennessy, J. "Some Recorded Extremes of Meteorological Elements." *The Marine Observer*. London, January 1933.

given in the Appendix) and the Persian Gulf, coupled with the high temperature, is very oppressive. Rainfall is everywhere scanty or practically nonexistent. The mountainous districts of Oman in the extreme southeast have about ten inches of rain and there is some rain, and occasionally snow, on the tablelands of the western part of Arabia. The mountainous region of Yemen in the southwest receives considerable rain from the summer monsoon; it has a rich agricultural country above 5,000 feet elevation.

The Syrian desert extends northward between Palestine and the plains of Mesopotamia. Coastal areas of Palestine and Syria, like most other regions bordering the Mediterranean, have relatively warm rainy winters and hot dry summers. On the coast of Syria and Palestine rainfall and humidity decrease from north to south. There is 35 inches of rain at Beirut and 12 at Gaza on the south coast of Palestine. Rain diminishes away from the coast

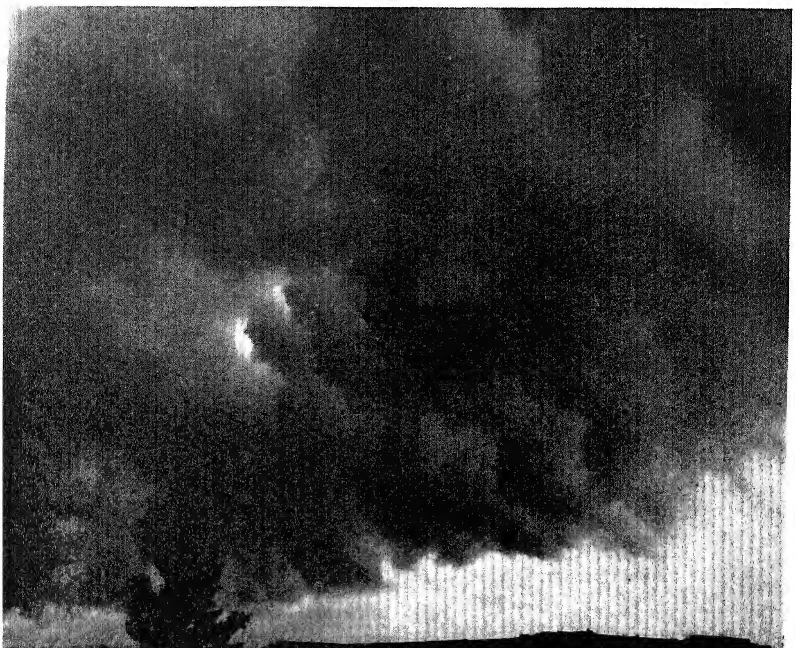


FIG. 42. Squall on the front of the monsoon. (C. E. Deppermann)

but increases again in the Lebanon Mountains where locally there is 60 inches. With some further irregularities it decreases again, and east of the River Jordan we come to the desert.

In the interior the winters are cold and dry, with frost and occasionally snow. Summers are hot and dusty. Records for Jerusalem are given in the Appendix. There is no climate in the United States like that of Palestine. The winters are like some parts of central Texas but without the extreme cold that occasionally is felt in the interior of Texas. The summers in Palestine and Syria are not so consistently hot as central Texas but temperatures in Palestine are often above 100° and there is never any rain. Irrigation is necessary in much of this area.

The plains of Mesopotamia and much of the valleys of the Tigris and Euphrates form the country now known as Iraq. The winters have an alternation of (1) warm southeasterly winds with clouds and rain and (2) cold dry northwest winds with clear skies. January averages 40° at Mosul and 49° at Baghdad. Snow falls occasionally. The total rainfall is about 10 inches except in the south, where it is only about 5 inches. In spring there are thundershowers. Rain and melting snow in the upper valleys cause floods in the rivers.

Practically no rain falls from June to October; strong northwest winds are constantly felt. It is very hot in summer, the sun intense, and the sky clear except for dust. The natives spend the daytime in underground chambers. Records for Baghdad are given in the Appendix.

To the eastward is the plateau of Persia where the January mean temperature is only a little above freezing and summer is as hot as in Baghdad. The middle of the plateau is a desert, but there is much rain around the southern borders of the Caspian Sea. There is no climate in the United States like Iraq and Persia. Yuma, Arizona, approaches it in temperature, but Yuma is not quite so hot in summer and is warmer in winter than much of this region. Records for Bushire and Tehran are given in the Appendix.

Most of Turkey in Asia is the plateau of Asia Minor. It is dry and very warm in summer and cold in winter. The coldest part of the plateau averages below 10° in January. Ankara has 10 inches of rain with a mean temperature of 32° in January and 72° in July. This temperature range is nearly the same as at New York City but the climate is of the plateau type and is entirely different from New York. Salt Lake City is a little colder in winter and warmer in summer than Ankara but otherwise a better example. Some rain falls throughout the year on the plateau of Asia Minor, except that much of it is in the form of snow in winter. Along the north coast there is much rain and cloudiness from the Black Sea, especially, in the east. The western coast is drier. In summer there are sea breezes during the day all along this coast.

The higher elevations are colder. Siras (4,400 feet) has an average of 21° in January and 67° in July.

On the south and west coasts we find the usual Mediterranean conditions, with very warm, dry and dusty summers marked by a daily sea breeze on the immediate coast. Rain falls in winter and spring and amounts to 20 or 25 inches. At Smyrna the temperature averages 46° in January and 81° in July, or quite like the coast of South Carolina.

All of this vast area along the Mediterranean and in the Middle East was the seat of ancient civilizations. Such hot climates have not favored a high degree of modern civilization, but there is no definite assurance that the climate of this area was decidedly different in ancient times.

CHAPTER XI

AFRICA

Eastern Atlantic Islands

Off the coasts of Africa there are several islands with interesting climates. Just south of the Cape Verde Islands lies the ocean area which is the place of origin of many of the severe hurricanes of the West Indies and southern United States. From this region they move westward or west-northwestward across the Atlantic and some of them finally cross the Gulf of Mexico or South Atlantic coasts (Fig. 7). This happens most frequently in August or September when the belt of doldrums is farthest north in the region south of the Cape Verdes.

The climate of the Cape Verde Islands is tropical. At St. Vincent February is the coolest month with a mean temperature of 70°. September is warmest, 78°. No rain falls from February to June, and the air is dry and dusty. During these months the wind is east, and relatively cool water rises to the surface along the coast of Africa. August and September are hotter with rain which continues into December or January.

Along the northwest coast of Africa are the Canary Islands, Madeira and Teneriffe. They are cooler than the Cape Verde Islands. Funchal, Madeira, has an average temperature of 59° in February and 72° in August. Rain falls mostly in the cooler half of the year. July and August are very dry with considerable dust from Africa. At La Laguna in the Canary Islands (1,800 feet) January averages 55° and August 70°. There is plenty of rain in the cooler half of the year. It is warmer at sea level with less rain and the summers are very dry. The climate at La Laguna is very much like that of San Diego.

The Azores lie about 600 miles northwest of Madeira but they have almost the same temperatures. Records for Ponta Delgada are given in the Appendix. There is more rain in the Azores in

summer than on Madeira but both have moderately wet winters and dry summers. The anticyclone or "high" of the eastern North Atlantic lies almost over the Azores in summer, and the winds are light, chiefly from the northeast. In winter, high pressure lies farther south and the winds of the Azores are a part of the prevailing westerlies.

On the other side of the Equator there are two islands of some importance historically—Ascension and St. Helena. Ascension Island was uninhabited until it was garrisoned by the British at the time Napoleon was banished to St. Helena. Both islands lie in the southeast trades and have very stable climates. Records for Ascension Island (height 52 feet) are given in the Appendix. St. Helena at sea level is slightly cooler than Ascension; it is about 12° cooler at 2,000 feet elevation. Rainfall increases with elevation, being about 6 or 7 inches at sea level and at high levels 25 inches (Ascension) and 40 inches (St. Helena).

Tropical West Africa

Practically all of the coast of West Africa in the great indentation between Cape Verde and Cape Lopez is hot, rainy and humid. South of the Equator the rainfall diminishes. Examples are Bathurst on the western bulge of Africa, Lagos on the Gulf of Guinea just north of the Equator, and Loanda on the coast about 10° south of the Equator. Records for these places are given in the Appendix. At Bathurst most of the 50 inches of rain falls in late summer and autumn. Lagos has 72 inches spread through all months but least in winter. Loanda has only 12 inches, mostly from November to April, the warmer half of the year in the Southern Hemisphere.

Rainfall is very heavy in Sierra Leone and Liberia, also near and east of the Niger River. In both of these coastal areas, more than 100 inches of rain falls and in places there is 150 to 200 inches. The west side of Kamerun Peak has over 400 inches. This part of Africa is known as the "white man's grave."

Diminishing to the southward of the Equator, rain becomes scanty from Cape Frio nearly to Capetown. This deficiency is

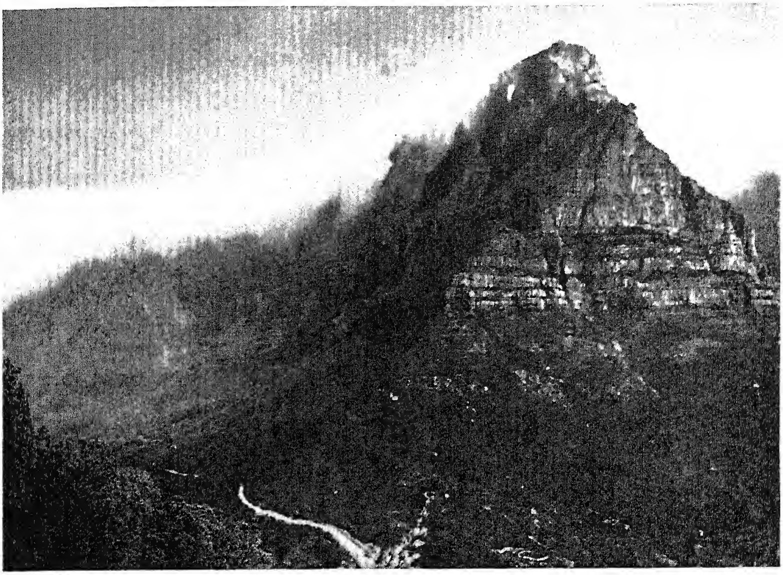


FIG. 43. Upper—Tablecloth cloud on Table Mountain, Capetown, South Africa. Lower—Clouds over Egypt seen from R.A.F. plane, with Nile River in middle and right foreground. Small cumulus below, altocumulus above.

caused by the presence of the cool Benguela Current and the overlying cool air which becomes warmer and drier as it blows into Africa.

Central and Southern Africa

The Congo basin occupies much of the western part of equatorial Africa. It is surrounded by plateaus. The basin is warm and humid; the seasons have little significance except in the distribution of rainfall, which is mostly in the form of thundershowers.

Most of the remainder of central and southern Africa is plateau with irregular topography and varied climates, but none of it is cold.

At sea level in the extreme south the mean temperature ranges from 62° in July to 80° in January, while the means for July and January at high elevations in the south are: Windhoek (5,500 feet), 56° and 74°; Johannesburg (5,925 feet), 51° and 66°; Kimberley (4,000 feet), 51° and 76°. Extreme southwestern Africa is dry. The Kalahari Desert lies north of the Cape of Good Hope.

Going around the southern tip of Africa by water we find a variety of marine climates in about the same order as on the South American trip (Chapter IX). After the hot, humid, showery weather of the doldrums, the ship reaches the southeast trades which prevail from the Equator nearly to the Cape of Good Hope, with slowly falling temperature as the ship steams southward. We must keep in mind that the seasons are reversed and the lowest temperatures come in July and August. At Capetown, the coolest month, July, has a mean temperature of 55°, rain about one day in three, and cloudiness about 50 per cent; this is very nearly like May weather in Chicago or December weather at Galveston. Summer weather at Capetown (December to February) is very nearly ideal.

Extreme southern Africa is under the influence of the prevailing westerlies much of the year, but more continuously in winter. In the waters south of Africa the "Roaring Forties" prevail just as they do at the southern tip of South America. As this belt moves northward in the southern winter, gales are more frequently experienced near the Cape of Good Hope (Fig. 6).

Along the east coast of Africa, temperatures rise rapidly northward to Mozambique where the summers are hot and the winters pleasant, and on to the coastal region between Mombasa and Aden where the weather is nearly always hot and frequently oppressive in all months.

Tropical cyclones form south of the Equator in the Indian Ocean and move westward toward Africa (Fig. 7). A few of them have gone as far westward as the Mozambique Channel before turning to the south and southeast. Tropical cyclones are unknown in the South Atlantic Ocean.

The East Coast and Nearby Interior

Durban, one of the principal ports on the southeast coast of Africa, is a winter resort. Many people from the highlands come to this port for rest and recreation during the cold July weather. This is partly explained by the daily range of temperature in the interior; the mean July temperature at Durban is 64°, and at high elevations in the interior the mean is about 50°, but the daily range is 21° at Durban and 30° or more at high elevations where the nights are quite cool and frost is common. Winter and early spring is the season of least rain at Durban.

Farther north winter is not so cool at high elevations. Entebbe (records in Appendix) on Lake Victoria (3,800 feet) has a mean temperature of 69° in July and Nairobi (5,400 feet) nearby, 59°. This part of east Africa and the Plateau of Abyssinia (Ethiopia) are the principal sources of the waters of the Nile River. The summer rains and thundershowers of Ethiopia yield the annual flood waters of the Blue Nile and Atbara Rivers which in turn produce the floods of the Nile in Egypt. Addis Ababa (8,000 feet) has a mean yearly temperature of 62°, with 66° in May and 59° in December. Its annual rainfall is 50 inches, of which about 30 inches falls in June, July and August.

The low country in Somaliland on the eastern tip of Africa is drier; the immediate coast is arid, hot in summer and very warm in winter. Aden (records in the Appendix) on the Gulf of Aden has much the same climate, but the coast around Berbera is hotter.

Fig. 44. Towering cumulus. (C. E. Deppermann)

There is no summer climate in the United States like it except in the deserts of Arizona and California.

Madagascar

Madagascar is one of the largest islands on earth, only Greenland, New Guinea and Borneo being larger. Its climate is tropical in character modified by topography. Throughout the year, it is in the southeast trade wind belt with temperatures on the east coast ranging from a January mean of 79° to a July mean of 69°. Extremes of temperature are not marked; the lowest of record (Tamatave) is 59°, the highest 97°. Rain is heavy most of the year with a total of about 130 inches, January, February and March having the most, and November the least. (Records for Tamatave will be found in the Appendix.)

The highlands are cooler. Antananarivo (4,600 feet) is 10° to 12° cooler than Tamatave, with a wet summer (December to March) and dry winter. The lowest temperature of record at Antananarivo was 41°.

On the west coast it is hotter and drier than the east coast, the averages being about 5° higher than Tamatave. Rainfall decreases from the north coast (over 60 inches) to the southwest where the coastal area is dry (less than 15 inches).

Mauritius and Reunion, small islands to the eastward of Madagascar, are essentially tropical in character but with stable marine climates and rainfall which varies greatly with elevation. Very heavy rains fall when tropical cyclones cross the islands, accounting partly for the heavy rains in the hills which average nearly 150 inches a year locally. Records for Mauritius (at the Royal Observatory, near sea level) are given in the Appendix.

CHAPTER XII

ASIA

Africa is the hot continent and Asia is the continent of weather extremes. Asia has desert lands and the world's heaviest rains; it has tropical heat that almost equals that of Africa, while Siberia has the coldest weather on earth; it has a vast system of winds called the monsoons which in magnitude are second only to the entire wind system of the globe; the annual change in atmospheric pressure over Asia is the greatest in the earth's atmosphere; and in addition, Asia has the unknown climate of the world's highest mountains, while over the warm seas near its shores it has more tropical storms than in all the remainder of the world.

India

Going eastward by ship we approach India either through the Red Sea, the Gulf of Aden and the Arabian Sea or around Africa and through the Indian Ocean. In either case, the weather during our approach to port in India depends on the monsoons. In Figures 23 and 24 we see how completely the wind changes with the season. In the Indian Ocean to the east of Madagascar, easterly winds prevail all year, gradually turning to southeast in summer and back to east or east-northeast in winter. These winds are warm and moist, having traveled over a great expanse of ocean. To the northward of the latitude of Madagascar, there is a complete reversal of wind with the season. In May the winds are southeast to the north of Madagascar, turning in a broad arc through the Arabian Sea toward India. By June the summer monsoon "bursts," as they describe it in India, and there is a complete change of weather over the entire southern and southeastern continent of Asia.

Moist winds pour into India as into a great funnel. Heavy rain falls along the west coast of India and Ceylon, amounting to more

than 75 inches in the season from June to October. Tremendous rains fall on the western shores of Burma and in the mountains facing the Bay of Bengal. Rainfall reaches its maximum on the slopes of the Khasi Hills of Assam, where the official averages per annum at various points of record run from 425 inches to nearly 500. More than 100 inches falls here each month in June, July and August.

During all of the summer monsoon period from June into September India is hot, moist and rainy except the extreme northwest (The Thar Desert and Baluchistan), where it continues dry. In the latter area, the winds are drawn down from the interior, also from Persia, Arabia and Somaliland, and vast quantities of dust are swept out over the Arabian Sea and carried along in the monsoon toward India.

The southwest or summer monsoon brings a certain amount of relief from the heat of spring and early summer. To understand the heat which prevails, we can imagine India moved in the same latitude around the globe to North America. The southern tip of India would reach into the Pacific as far south as the Panama Canal. The extreme north of India in the Himalayas would reach into Colorado. Northeastern Burma would touch Florida, and Baluchistan would protrude into the Pacific from northwestern Mexico.

The summer monsoon becomes established by July and continues with occasional interruptions until October. During intervals when the monsoon weakens, the temperature rises. The chief difference is in daytime temperatures; they are lower during the rains, but night temperatures continue high.

In October and November, the northeast monsoon replaces the summer monsoon. The rains cease over most of India, and the temperature gradually falls in the northern part. January and February are cool, dry, and cloudless in the Punjab, the United Provinces and northern India generally. At this season the extreme northwest has temperatures about like winter in southern Texas including the Rio Grande Valley, while the southern part except the coast has temperatures like southern Florida. Calcutta

in winter has about the same mean temperature as Miami. The southern coasts continue hot in winter with average temperatures 76° at Bombay, 80° at Colombo, 76° at Madras and 77° at Rangoon, equal to summer heat in Tennessee. However, this is the only really comfortable season in India for an American.

As soon as the northeast monsoon weakens at the end of February or first of March, the temperature begins to rise and it becomes uncomfortably hot by April or May. Average temperatures in May exceed 90° over all of the interior of India and are above 95° in the central part. Daytime temperatures rise above 110° over northwest and central India. There is no steady heat like this in

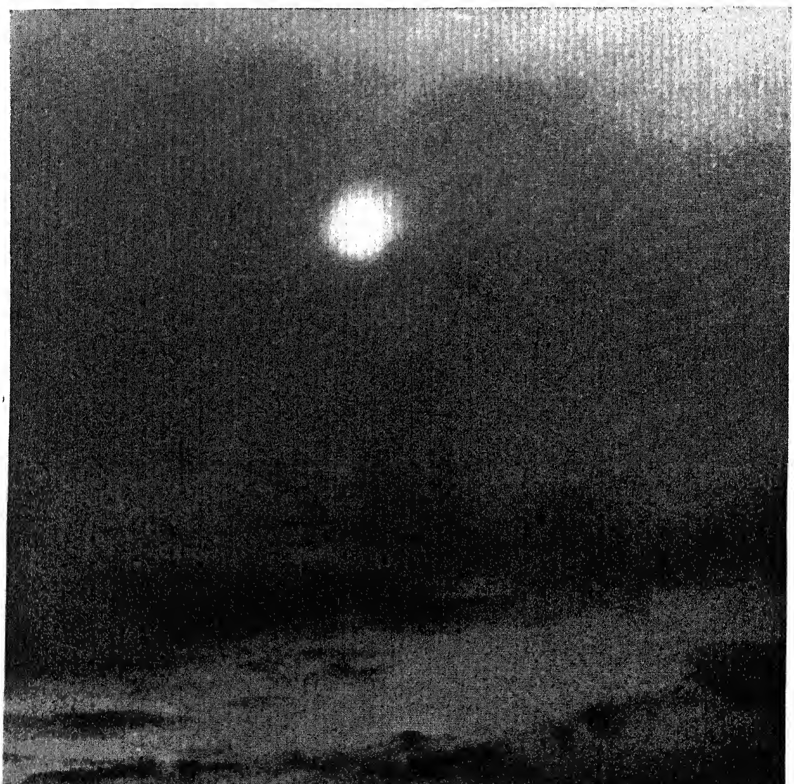


FIG. 45. Sun seen through altostratus with typhoon in the China Sea. (C. E. Deppermann)

the United States except midsummer in the Arizona and California deserts.

Although the summer monsoon beginning some time in June brings heavy rain to the western shores of India and the southwest portion of Ceylon, the interior to the lee of the Western Ghats has only about 20 inches. Heavy coastal rain does not extend much to the northward of Bombay. Karachi has only 6 inches.

Rains are heavier in the direction of the Ganges River. Calcutta has about 60 inches a year. Heavy rain usually begins there in June. Until the monsoon arrives, the heat in June is very oppressive at Calcutta.

Broadly speaking, India has three seasons, the cool or cold weather from November to March, the hot weather from April into June, and the rains beginning in June and continuing into October.

Extreme Northern India

There are, of course, some cold sections in northern India. Leh, in the extreme north, is at the crossroads of India, Chinese Turkestan and Tibet. Leh is in the elevated valley of the upper Indus River, in the interior of the Himalayas, the highest mountain range on the globe, which separates India from the vast interior of Asia.

Leh has been the starting point of many adventures into Tibet. The usual course toward Mt. Everest is up the Indus Valley to the Manasarowar Lakes and down the Valley of the Tsangpo (or Brahmaputra) River. The pass is about 15,500 feet above sea level. The Tsangpo is navigated for 400 miles at an elevation of 12,000 feet above sea level. Lhasa, the capital of Tibet, is situated on a tributary of the Tsangpo. Both these great rivers, the Indus and Tsangpo, rise in the glaciers of the Himalayas. It was only in the present century that the Tsangpo was definitely identified as the upper part of the Brahmaputra. The valley at Leh is 11,500 feet above the sea. The mean January temperature is 17°; the temperature has been as low as 19° below zero. July at Leh is fairly warm with a mean of 63°.

Afghanistan

In the northwest of India and in eastern and northern Afghanistan, the mountains are not quite so high as in the main range of the Himalayas, but the weather is very severe in winter. From the city of Kabul eastward through high passes on the route to Jalalabad and Peshawar, invading armies have sought the riches of India. Khyber Pass is on the principal road from Afghanistan to India; it is one of the most important military roads in the world.

In 1842 during the first Afghan war, after the British leaders were assassinated in Kabul, the army of 4,000 soldiers and 12,000 camp followers set out for India in the dead of winter. Only one survivor reached Jalalabad, most of the remainder having succumbed to the weather. We are told that Alexander the Great was successful in taking an army through these passes in 327 B.C.

The climate in the north of Afghanistan is extreme. Cold waves in winter reach 10° or more below zero. The southern part around Kandahar is not so cold in winter but suffers from summer heat and dust storms. Temperatures rise to 110° or 120°. The summer monsoon does not bring rain to Afghanistan; it gets its moisture from winter snows and light spring rains, largely with winds from the northwest.

Tibet

The great plateau of Tibet lies more than 12,000 feet above sea level, except the southeast portion where it is lower in the valley bottoms. It is the highest country in the world, though the densely populated basin of Lake Titicaca in Bolivia is almost as high. The plateau of Tibet is 1,200 miles long and varies in width from 400 miles in the west to 700 miles in the east. Little is known about the climate. Some records have been made on expeditions into the country. They indicate average July temperatures ranging from 60° in the lower elevations (10,000 feet) to about 40° degrees at 15,000 feet. Winter is extremely cold with a large range of temperature between day and night. A temperature of 40° below zero was recorded by one traveler.

In the eastern part of Tibet rain falls mostly in July and August;

the total in a year is probably 10 to 20 inches. In the western part it appears that most of the moisture is received in the form of snow in the colder part of the year. In the higher lands violent winds are common, especially in the daytime, often blowing a great deal of snow, even in summer.

Siberia and Central Asia

Beyond Tibet and the Kwen Lun Mountains the continent of Asia slopes irregularly toward the northwest into Siberia and toward the north through the rainless district in Mongolia and on into eastern Siberia. Weather records have been kept at scattered places in this vast region of central Asia with its rugged topography and varied climates, mostly mountain, plateau and desert. The Appendix contains records for Tashkent, Luktchun, Barnaul and Irkutsk which give some indications of conditions in this vast central area which is the seat of the great Asiatic anticyclone in winter. The rainfall (and melted snow) amounts to less than 10 inches a year in most of the central area, and between 10 and 20 inches in Siberia.

Summer in Siberia is short. Except in the extreme north and northeast the mean temperature rises above freezing in April and goes below freezing again in October with a short season in midsummer with mean temperatures above 60°. In the far north and east of Siberia (Turukhansk, Verkhoyansk, Okhotsk, Novo Mariinsk, and Petropavlovsk in Table V of the Appendix) the mean temperature is below freezing until sometime in May and goes below again in September in the far north and October in the far east. The brief summer has average temperatures near 60° in the far north and near 50° in the far east. Vladivostok, in the extreme southeast, is not so cold. Winter is severe in all this vast area of Siberia and central Asia. In Siberia the January mean is generally 10° to 20° below zero, diminishing toward the cold pole of the world at Verkhoyansk where January averages 58° below zero and the temperature goes to or near 80° below zero every winter. As noted earlier, the lowest recorded there was 94° below zero, the world's record low temperature.

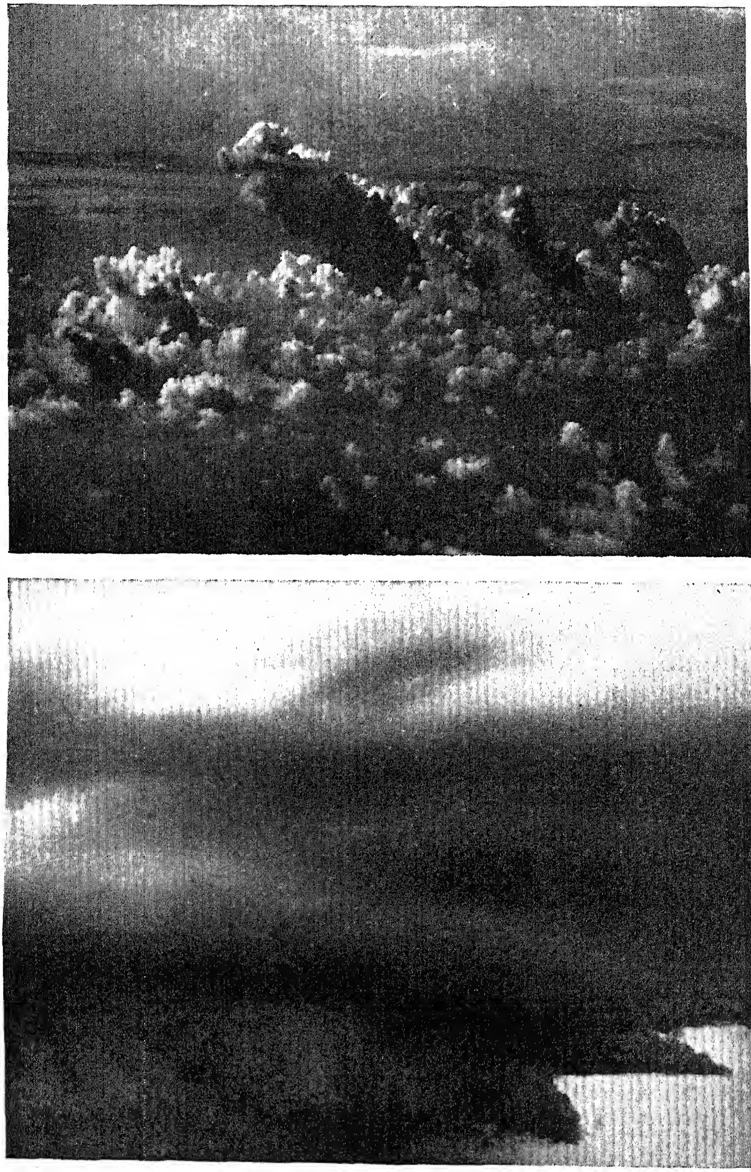


Fig. 46. Upper—"Heaped-up" clouds (cumulus) seen from airplane. Lower—Front of a tropical squall at Manila. (C. E. Deppermann)

China and Southeastern Asia

China, Indo-China and Siam, like India, are monsoon countries with a wind system which is associated with the tremendous seasonal temperature and pressure variations over the interior of Asia. In China there are good weather records in the coastal regions but not much is available from the vast interior. In winter strong winds blow down from the deserts, often carrying clouds of dust out over the China Sea. These winds are very cold in the north. The mean temperature of the Great Plain in the north of China is generally between 32° and 20°. Manchukuo is colder. At Mukden January averages 9°, at Peking 23°, at Shanghai 38°. At Chungking, which is sheltered from the cold winds by mountains, the average winter temperature is about 50°. At Canton in the southeast, January averages about 60°. If we could place eastern Asia over North America with Manchukuo over Quebec, Peking on the Maine coast, Shanghai on lower Chesapeake Bay, and Canton at Jacksonville, Florida, we would have winter temperatures about the same. Indo-China and Siam are warmer, Saigon and Bangkok having winter temperatures as high as summer heat at Miami.

In April the summer monsoon starts in southern China. By May the monsoon rains are reaching into northern China; they continue from June to September; in October dry winds from the interior begin and the winter monsoon prevails in November and throughout the winter.

China is hot in summer, with temperatures as high as in southeastern United States. Rain is heavy in the south of China. Hong Kong has 84 inches.

Indo-China is hot and damp from April to October, but April and May are the hottest. More than 60 inches of rain falls over much of Indo-China. Annan is dry and very hot in June, July and August. Siam is humid and hot. The weather is less disagreeable from November to February, but the remainder of the year is very oppressive. Between the monsoon rains, the weather is hot and steamy.

The Malay Peninsula also has a tropical climate, and though

the temperature does not rise to great extremes as in India, the humidity is very high and the weather uniformly oppressive. Rainfall on the east coast is about 120 inches a year and on the west coast 60 to 120 inches.

Japan

The extent of Japan in latitude, from the Kuril Islands to Formosa, is equal to that from Newfoundland to Cuba, and the climates of the islands are correspondingly varied. Japan feels the monsoons of Asia, and in general the islands have short but hot and humid summers and long, clear and cold winters.

In Tokyo the temperatures the year round are about like eastern North Carolina, but Tokyo has more rain than the eastern coast of the United States. In the mountainous sections of Japan deep snow covers the ground all winter.

Typhoons have caused much loss of life and property in Japan. In the great disaster at Tokyo on September 1, 1923, a typhoon was a contributing factor. An earthquake started fires over the city as a typhoon was passing Yokohama. The winds of the typhoon, without rain, reached Tokyo in time to fan the flames, which spread with great rapidity. There were nearly 100,000 known dead, more than 100,000 injured, and nearly 50,000 missing.

The Kurils are severely cold for four months in winter. On the other hand, Formosa has a tropical climate and the mean temperature falls below 60° only in January, except that it is cooler, of course, at higher elevations in the island.

Korea has a good climate for 9 months of the year. Summer is rainy, warm and damp. At Seoul the mean temperature range is from 33° in winter to 75° in summer.

Tropical Storms

Tropical cyclones occur in the Arabian Sea and the Bay of Bengal (Fig. 7), principally in the warmer months, with an average of about two a year in the Arabian Sea and ten a year in the Bay of Bengal. The China Sea and the western Pacific Ocean east of the Philippines and northward to Japan is a region of great

frequency of tropical storms; in this part of the world they are known as "typhoons." As a rule, they originate over the waters east of the Philippines, possibly as far east as the date line (180°) and move westward or northwestward into the China Sea or turn to the northward in the vicinity of Japan. An average of twenty to twenty-five annually are reported in this region; they occur occasionally in every month but are most frequent from June to October.

On the low coasts of China and India, tropical storms have been very destructive to life and property. The "Fiercest Cyclone of the Nineteenth Century" was the description of the tropical storm at Backergunge, India, in 1876. This cyclone was attended by an enormous storm wave which swept over the islands and lowlands at the mouth of the Megna River. It was estimated that the loss of life from drowning was 100,000 and that 100,000 more died from disease as a result of the inundation. The Calcutta cyclone of 1864 drowned an estimated 50,000 persons, with 30,000 more dying of disease afterwards. An earlier cyclone (1737) at Calcutta was more destructive to life; it is said that the storm wave rose to a height of 40 feet and that 300,000 persons perished in Lower Bengal or in the Bay. While these estimates may have been exaggerated, the low coastal areas are densely populated in places and there is no doubt that the loss of life was enormous.

Similar catastrophes have occurred on the low coasts of China. A typhoon at Haifong in 1881 was one of the most destructive. Loss of life there was estimated at 300,000.

Of course, these storms have caused great losses to shipping also. The Calcutta cyclone of 1737, for example, destroyed an estimated 20,000 boats of all descriptions.

In the same part of the world, there occurred the terrible eruption of Krakatoa in August 1883. It was a volcanic island in what is now the Sunda Strait. The top of the island, where it rose as much as 1,400 feet above the sea, was blown off in several violent explosions, leaving a submarine cavity more than 1,000 feet below sea level. The actual sounds of the explosions were heard at distances of 1,500 to 3,000 miles. A tremendous sea wave was pro-

duced which reached a height of more than 100 feet on the opposite Java shores. More than 36,000 human beings perished. Dust and ashes were thrown more than 17 miles high. At Batavia, more than 100 miles away, it was so dark at noon that lamps had to be used indoors.

The Krakatoa eruption is mentioned here because of its effects on the weather. Vast quantities of dust high in the air were gradually distributed over the entire globe. On account of the scattering or absorption of the shorter rays of light, the dust veil produced fiery skies over much of the world for the next two or three years. The glow above the horizon was so vivid in one American city that the fire department rushed out to put out what was thought to be a big fire in a town nearby. A veil of volcanic dust absorbs, reflects and radiates into space some of the heat that would otherwise reach the surface of the earth. This is thought to have caused the unusually cold weather that followed the Krakatoa eruption. There have been other cases. An example is the "year without a summer" (1816) which followed the eruption of Tomboro in the East Indies. Snow which fell in June, July and August 1816 in New England was possibly a result of this eruption.

CHAPTER XIII

AUSTRALIA AND THE PACIFIC ISLANDS

Australia is the flat continent. About equal in area to the United States, it may be considered either the smallest continent or the largest island on earth. It is mostly a low plateau; in fact, it has the least average elevation of all the continents, and its outstanding geographical features are flatness and distance. The climate of Australia is correspondingly simple, without the strong contrasts that prevail under the influence of great mountain barriers on other continents.

All of Australia is south of the Equator. If we could swing it around with the northern tip 10° north of the Equator instead of 10° south, Port Darwin would lie just north of the Panama Canal and Tasmania would be in Nebraska. However, the ranges of temperature and variations in climate in other respects are by no means as great as between the Canal Zone and Nebraska. The vast ocean areas surrounding Australia serve to temper the climate, especially in the south. Hobart, Tasmania, is as far from the Equator as Vladivostok, but a comparison of the records for these two places in the Appendix (the seasons are reversed) will quickly show the extent of continental and marine influences. For example, in the coldest month, Hobart (July, 46°) averages 40° warmer than Vladivostok (January, 6°), while in the warmest month, Hobart (January, 62°) averages 8° cooler than Vladivostok (August, 70°).

Summer in northern Australia (December, January and February) is hot. In January, all of the northern half of the continent and much of the southern interior have mean temperatures above 80°; the northwestern and northern interior have means above 85°. (Records for Alice Springs, Broome, Carnarvon, Cloncurry, and Darwin are given in the Appendix.) It is like Texas in July.

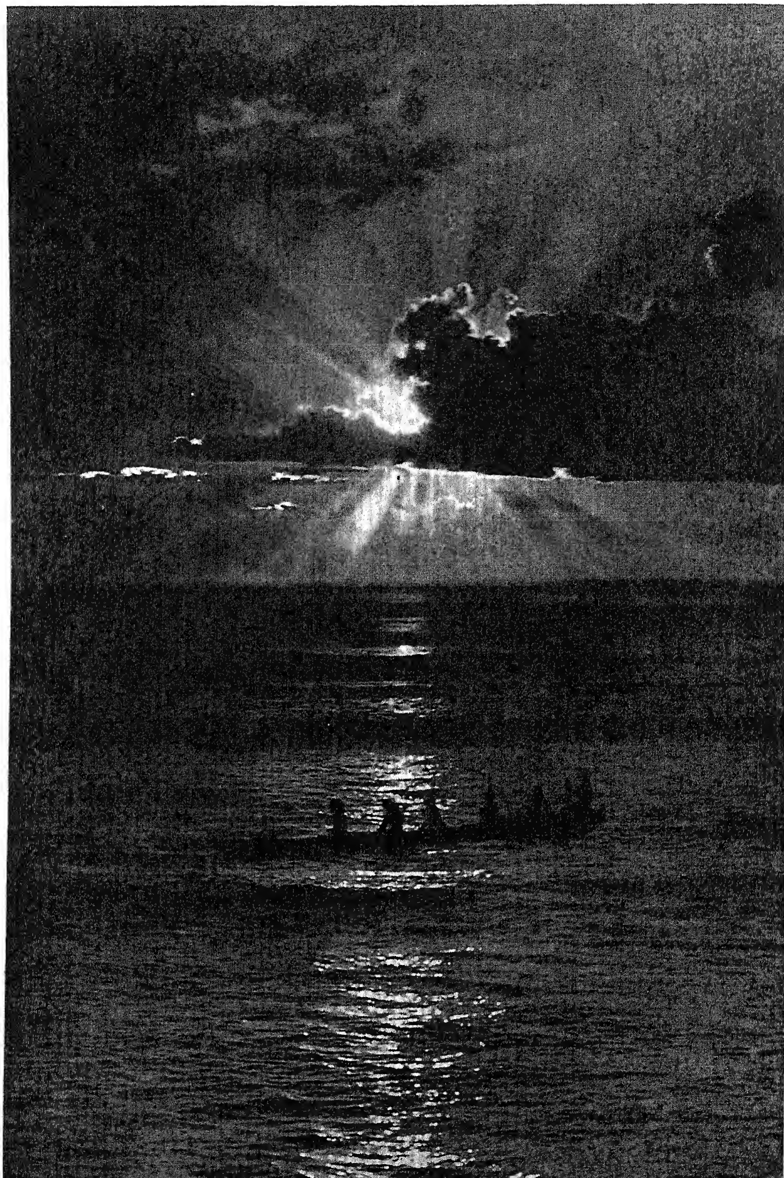


FIG. 47. Cumulus clouds spreading out at sundown to form stratocumulus, with crepuscular rays; on the Pacific Ocean near Honolulu.

In the far north, the temperature continues high in winter and as an average for the year this is one of the hottest places in the world. Wyndham, on Cambridge Gulf a short distance inland from the Timor Sea, has a mean annual temperature of 84.6°.

Southern sections near the coast are decidedly cooler in summer (Brisbane, Eucla, Melbourne, Perth, and Sydney in Appendix). Summer temperatures at Melbourne and Sydney average about the same as Portland, Maine, or Montreal. Tasmania is cooler in summer. Hobart with a mean January temperature of 62° is only slightly warmer than San Francisco in September.

In winter, the temperature in the extreme north averages 70° to 78°, or about like winter in Cuba. The temperature diminishes toward the southeast and averages near 50° on the south coast and below 50° in Tasmania and in the southeast of Australia. These temperatures compare favorably with winter on the Gulf Coast of the United States but Australia never experiences the low temperatures that are occasionally experienced in cold waves on the middle Gulf Coast. For example, the lowest of record at Melbourne and Hobart was 27°, while the temperature occasionally falls below 10° on the middle Gulf Coast.

Hot waves are not uncommon, however, in the south of Australia. Occasional hot, dry and dusty winds from the interior are a feature of the summer climate on the south and east coasts and even in Tasmania. In Victoria these hot winds are known as "Brick Fielders." Under these conditions the temperature has risen to 105° at Hobart and 111° at Melbourne. When hot northerly winds have prevailed for a day or more, there is a lull, sometimes followed by a sudden violent wind from the south called a "Southerly Burster." The temperature drops quickly, usually as much as 20°.

Australia, generally speaking, is a dry continent. Rainfall exceeds 50 inches on the tropical coasts of northern and northeastern Australia, most of which falls in the warmer half of the year. January is the wettest month in this area. On the extreme northeast coast, Cape York has over 80 inches and Harvey Creek more than 160. Rainfall diminishes rapidly toward the interior, and is less than 20 inches in all except the coastal regions and less than 10

inches in most of the central, south and southwest interior. The east coast also has more than 50 inches, mostly in winter, but there is more rain in summer here than on the north coast. The southeast and southwest coasts have 30 to 40 inches which is fairly well distributed throughout the year. Tasmania has 20 to 30 inches in the east, also well distributed, but the western slopes of the mountains have much more, mostly in winter and spring. In places in the elevated sections of the west and north, the total annual rainfall varies from 100 to 140 inches.

The driest part of Australia is around Lake Eyre where the annual rainfall is less than five inches.

Tropical cyclones on the west coast of Australia are known as "willy-willies"; they occur from December to April. Originating in the seas to the north of Australia, they move first to the southwest and then turn to the southeast at about 20° south latitude. They are of the same class as the West Indian hurricane and the typhoon of the Far East. The east coast is occasionally visited by a hurricane which comes from the vicinity of the Fiji, Samoa or Tonga Islands, though the hurricanes of this area are likely to turn southward before reaching Australia (Fig. 8). There, also, the season extends from about December to April.

New Zealand

New Zealand lies in the zone of the prevailing westerlies throughout the year. It extends from 33° to 47° south of the Equator. The Pacific Coast from San Diego to Seattle is about the same distance north of the Equator and, in fact, the temperature of New Zealand is more like that of the Pacific Coast than any other part of the United States. Auckland has a range of temperature from 52° in winter to 67° in summer, while at San Diego it is 54° to 68°.

South Island is cooler. Dunedin, in the extreme southeast, is about 10° cooler at all seasons than Auckland.

New Zealand has higher mountains than Australia. The Southern Alps extending from the northern part of South Island along the west coast are 3,000 to 6,000 feet in height, with detached

peaks 8,000 to 9,000 feet high. Mt. Cook is 12,349 feet high. On the ridges and peaks there is perpetual snow.

On the western slopes of the mountains, rainfall is heavy. A wide strip of South Island receives more than 100 inches a year, and the higher lands have 200 to 300 inches, much of it snow. The great snow-fields are drained by glaciers, one of which descends within 700 feet of sea level.

The eastern part of South Island is sheltered from the prevailing wind and has moderate rainfall varying locally from 20 to 40 inches. On North Island the rainfall varies from 30 to 60 inches, with considerably more locally at higher elevations. On both North and South Islands, rainfall and cloudiness are fairly evenly distributed through the year, and there is more sunshine than would be expected in a marine climate of that nature.

New Guinea and the East Indies

New Guinea lies just south of the Equator. Except in the mountains the climate is tropical. There is little variation in the temperature except as it is affected by rainfall, and the rainfall in turn is controlled chiefly by the monsoons. In the northern summer the monsoon blows from Australia across the East Indies into Asia and in the northern winter, a branch of the northeast monsoon of Asiatic waters extends southward and southeastward across the islands into the low pressure of Australia.

The southern part, sheltered by the mountains from the northeast monsoon, is relatively dry. Port Moresby has about 40 inches of rain. Elsewhere the rainfall is as varied as the topography. On the northeast coast, Finsch Harbor and Bogadjim each have about 120 inches of rain, but they are on opposite sides of the mountains and Finsch Harbor has 3 to 4 inches per month from December to February and about 18 inches per month from June to August, whereas Bogadjim has 3 to 4 inches per month from June to August and 15 to 17 inches from December to February. This example shows how wind direction and topography cause extremely varied rain distribution locally in this region.

The southeast coast around Port Moresby is slightly less warm

from June to September, but on the whole New Guinea is oppressively hot and humid the year round except on the higher mountains. Snow may fall at any time of the year on the mountain peaks.

The same description applies to the islands of the East Indian Archipelago, including Borneo, Sumatra, Celebes and Java. All of this area is more or less dominated by the monsoons and is tropical, hot, humid and generally oppressive, the only exceptions being at high elevations where it is cooler. Rainfall is abundant and varies chiefly with topography and the seasonal changes of the monsoon winds.

The Appendix contains records for Amboina, Batavia, Port Moresby, Rabaul, Sandakan, and Singapore.

The other tropical islands not far from the Equator including the Solomon Islands and the Fiji Islands have a tropical marine climate, hot and moist, without extremes of temperature but with a general oppressive monotony from which there is slight seasonal relief from June to September on islands 10° to 15° south of the Equator and from December to March on islands the same distance north of the Equator. Suva has an average temperature of 80° in January and 74° in July.

New Caledonia is hot and moist in the southern summer and autumn (November to April) but, being more than 20° south of the Equator, is somewhat cooler from May to September. Records for Numea are given in the Appendix.

The average annual temperature in the Philippines is 80°. April to October are hot with averages from 80° to 82° and November to March are slightly less warm, 78° to 80°. The climate is controlled by the monsoons. The eastern part of the archipelago has plenty of rain throughout the year but most in winter. The western part is dry in winter and spring and wet in summer and autumn. The average rainfall for the islands is nearly 100 inches a year. Some very heavy rains occur in connection with typhoons. The world's heaviest rainfall in twenty-four hours—46 inches—fell at Baguio in the typhoon in 1911, as noted earlier. Records for

Manila are given in the Appendix. Although the Philippines extend through nearly 15° of latitude, temperature variations are very small. In the extreme north it is about 2° less warm in January than at Manila, and in the extreme south it is about 2° warmer. Summer is uniformly hot over the entire archipelago.

In the cooler part of the year, gales are not so prevalent on the North Pacific as on the North Atlantic, but there is usually stormy weather somewhere on the northern routes, most often in the northwestern parts of the ocean. As an average, the worst spot (Fig. 5) is along and just north of 40° north latitude and near and to the west of the International Date Line (180°). There is much cloudiness and rain (occasionally snow) on northern routes, especially in winter. Fog is prevalent in the warm season. Being on the great circle, the northern route across the Pacific is really shorter than the middle route, though it does not appear so on

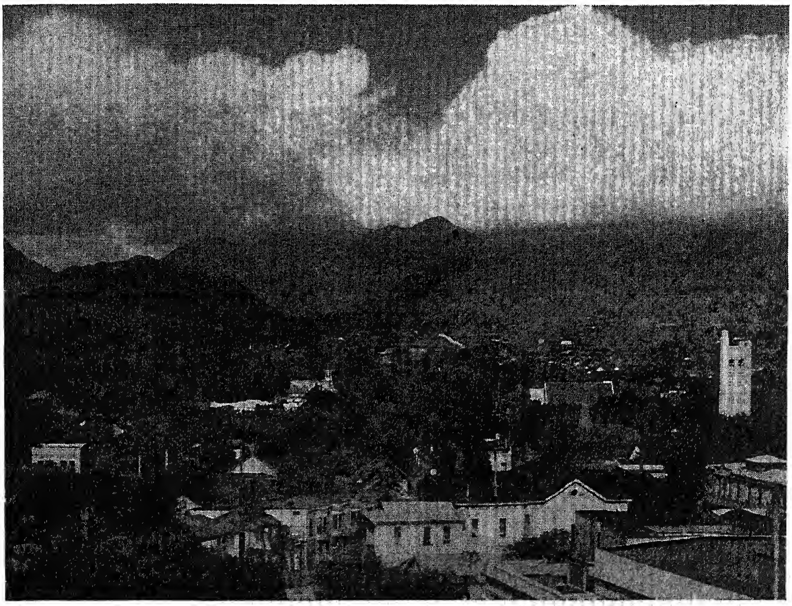


FIG. 48. Crest clouds seen from the lee of the mountains at Honolulu.

the Mercator maps generally used by mariners. On the middle routes, storms and fogs are avoided to some extent.

The Hawaiian Islands

Although the average temperatures at Honolulu are a little above the optimum, they are so decidedly better than the temperatures along most of the main North Pacific routes that they combine with the high percentage of sunshine and the dependability of the trade winds to constitute a climate that has given the city the name, "Paradise of the Pacific." There are no extremes of heat or cold, stormy weather is rare, and the distribution of rainfall in the islands is so varied that the traveler can find almost as much or little as he wishes. Even in Honolulu, every street is supposed to have a different rainfall. Certainly there are great contrasts in the islands; some of the southwest coasts in the lee of the mountains have less than 20 inches a year while some of the mountain slopes facing the trade winds have yearly falls running into the hundreds of inches, reaching what is nearly a world's record on Mt. Wailaleale with an annual rainfall somewhere near 500 inches.

"Kona" storms, as they are known locally, are strong southwesterly winds that occur occasionally in winter; they cause most of the rainfall in areas which, being in the lee of the mountains when the trade wind is blowing, are ordinarily dry.

From Honolulu through the northeast trades to the Panama Canal, the temperature rises gradually, winter and summer, until it reaches a daily mean of about 80° at the Isthmus. On the route from Honolulu to San Francisco it is decidedly different; the weather, as a rule, is good; cloudiness increases somewhat from Honolulu toward San Francisco; northerly and northeasterly winds are dominant; but the temperature gradually falls through the sixties and even into the high fifties in summer and into the low fifties in winter, as the ship nears the coast. If the trip is made between May and October there is likely to be fog in coastal waters. Near San Francisco the frequency of fog is 7 per cent in winter, 5 in spring, and 15 in summer and autumn.

Travelers who are interested in the frequency of storminess on

the route from Honolulu to San Francisco will find useful information in the table which follows:

TABLE OF STORMINESS*
(Frequency of winds of Force 7 and higher)

	(1)	(2)	(3)
January	4	5	6
February	3	5	6
March	3	4	7
April	2	2	5
May	1	1	5
June	†	1	6
July	†	1	5
August	1	†	3
September	1	†	3
October	1	1	3
November	1	3	4
December	3	4	7

* Numbers in column (1) in the table represent frequency of winds of Force 7 and higher over the first third of the route outward from Honolulu; column (2) in the middle of the route and (3) in the final third of the route, approaching San Francisco. The number 5, for example, means that winds of Force 7, or higher, prevail 5 per cent of the time. In the stormier parts of the oceans, winds of Force 8 and higher are presented, but storminess on the Honolulu-San Francisco route is small and gales *exceeding* Force 7 are seldom encountered.

† Less than 1 per cent.

West Coast Hurricanes

Between San Francisco and the Canal, the change in temperature is sometimes sudden. A cool ocean current sets southward with prevailing northerly winds; the ship leaves the Canal in tropical waters with temperature steadily in the low eighties or high seventies; along the coast of Lower California, it becomes decidedly cooler and warmer clothing is needed for the rest of the voyage northward.

This route is subject occasionally to tropical storms which form in waters off Central America and move northward or northwestward, sometimes passing inland on the Mexican coast as far north as Lower California (Fig. 7) but seldom having any appreciable effect on the coast as far north as San Diego.

Fig. 49. Fog pouring through the Golden Gate at San Francisco.

Tropical storms here are not nearly so frequent as the typhoons of the Far East; the records show only about five a year as an average; they may occur in any month from May to November but are most likely in September.

FIG. 50. Lenticular cloud above Mt. Rainier. (O. P. Anderson)

In winter, the coastal waters of Costa Rica and also the Gulf of Tehuantepec are occasionally visited by gales that blow out from the land, the result of cold weather to the northward. These winds are called "Tehuantepecers" or "Papagayos" after the waters in which they occur. They are akin to the "northers" of the Gulf of Mexico and the mistral winds of Marseilles. A similar wind, the "Santa Ana," sometimes with much dust, is occasionally felt in winter in the coastal waters of California, near Los Angeles, when pressure is high and temperatures are low in Nevada and Utah. Winds of this class are not common on the San Francisco-Canal route but on rare occasions they blow with great force and become dangerous to shipping in the harbors.

Far Southern Routes

From southern Australia and New Zealand, the routes around Africa and South America carry the steamer into high latitudes of the southern hemisphere, along the 40th parallel or to the southward. In summer (December to January) these routes lie along the northern margin of the "Roaring Forties" or the belt of gales in the southern oceans. In winter, the belt of gales is farther to the northward and gales are more frequent along the southern steamer routes (Fig. 6). The wind rises to Force 8 or higher on an average of one or two days out of a week. The range in temperature from winter to summer is not much more than 10° anywhere on these routes, as will be seen in Figures 27 and 28. Shifting winds, mainly between southwest and northwest, changeable weather, frequent rainfall and much cloudiness are the usual conditions. The winds have an uninterrupted sweep and commonly produce rough seas.

Maury, in his *Physical Geography of the Sea* gave this description of the "Roaring Forties" or "Brave West Winds":

"To appreciate the force and volume of these polar-bound winds in the southern hemisphere, it is necessary that one should 'run them down' in that waste of water beyond the parallel of 40°S, where 'the winds howl and the seas roar.' The billows there lift themselves up in long ridges with deep hollows between them. They run high and fast, tossing their white caps aloft in the air, looking like the green hills of a rolling prairie capped with snow, and chasing each other in sport. Still their march is stately and their roll majestic. The scenery among them is grand, and the Australian-bound trader, after doubling the Cape of Good Hope, finds herself followed for weeks at a time by these magnificent rolling swells, driven and lashed by the 'brave west winds' furiously."

CHAPTER XIV

NORTH AMERICA

Comparison of North America with Other Continents

Returning home after a view of the weather on other continents, we can look briefly at our North American weather and appreciate it as a part of the world picture. We have seen South America as the wet continent. Its vast tropical interior receives a tremendous rainfall which feeds the Amazon, the world's greatest river. Its southern extremity in cold latitudes is narrow and does not breed cold waves. The continent is warm and wet. Africa straddles the Equator. Its bulk to the northward contains a great desert. Excepting the heavy rains near the Equator, Africa is arid. Briefly, the continent as a whole is hot and dry but is very wet in spots. Europe has moderate rainfall and its temperature is mild for its latitude. Asia is the continent of extremes, broad in the north, but with mountain barriers roughly from east to west dividing the central deserts and the extreme cold of the north from the wet, tropical south. Australia is flat, dry and warm.

North America is more like Asia. Given a mountain barrier running from west to east its climate would be like that of Asia on a small scale, but this barrier is lacking in North America. Being broad in cold latitudes like Asia, it has great extremes of temperature. Owing to the north-south trend of the mountain ranges, with vast plateaus and plains between, its cold weather penetrates far to the south in winter, and its warm, moist winds bring summer rains to the far north.

In this great interior where there is no barrier between the cold north and warm south, there are sharp contrasts between air masses, and weather disturbances constantly move across the continent, giving its climate a varied character which exists nowhere

else in the world on such a scale. In winter, practically the whole continent north of the Mexican border yields to the assaults of cold air masses, while in summer nearly the entire continent is warm, with temperatures occasionally rising to or above 100° over most of the continent and above 90° even in northern Canada and Alaska.

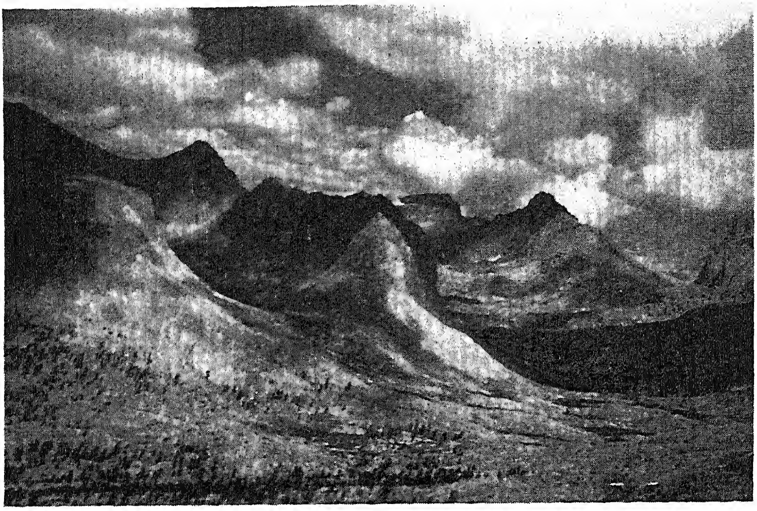


FIG. 51. Cumulus clouds gathering over the Sierras prior to a local storm. (L. H. Daingerfield)

These shifting air currents and variable temperatures make North America the home of the cold wave and blizzard, the tornado, the heat wave, the flood, "Indian summer," and the "January thaw." It is this variety all through the year which makes the American intolerant of the monotonous regularity of heat, cold, rain, and aridity that constitute the climates of other continents.

Alaska

The climate of Alaska has many interesting extremes. The Aleutians extend from 163°W to 172°E in the Pacific. They have

moderate temperatures, heavy rainfall, excessive cloudiness and almost constant fog. Winter temperatures are milder than on the coast of Alaska, and the summers are cooler. Along the Pacific Coast of Alaska temperatures are much more moderate than in the interior. Rain and snow are heavy on the coast southward to British Columbia, Washington and Oregon. This is the wettest part of North America. The total fall, most of it in winter, exceeds 100 inches in extreme southern Alaska and in the coastal areas of British Columbia and Washington and Oregon. Average winter temperatures are near or slightly below freezing from Dutch Harbor to Juneau, and average summer temperatures range from 50° at Dutch Harbor to 55° at Juneau. On the mainland bordering the Bering Sea it is colder. Nome has an average near zero in January; July averages about 50°.

Inside the coastal region south of the Alaska Peninsula is the Coast Range with the highest peak in North America, Mt. McKinley (20,300 feet) which rises above its surroundings higher than any other mountain in the world. To the northward is the Yukon Valley, where it is colder in winter (January averages 15° below zero at Tanana) and warmer in summer than the Bering and Pacific coasts (Tanana, 59° in July). Barrow on the north coast averages about 20° below zero in January and 40° in July.

Temperatures frequently fall to 50° or 60° below zero in the interior of Alaska and occasionally more than 70° below zero in the upper Yukon Valley and in the lower Mackenzie Valley in northwestern Canada. This is the coldest spot in North America in winter. The mean temperature is below freezing for eight months of the year. The Appendix contains records for Dutch Harbor, Juneau, Nome and Tanana.

Canada

The vast area east of the mountains as far as Hudson Bay and the Great Lakes receives more moisture in the warm part of the year than in winter. This is true of practically all of Canada and the United States, whereas the Pacific coastal area receives nearly

all of its moisture in winter. In the east, moisture from rain or snow is fairly well distributed throughout the year.

From the lower Mackenzie Valley southeastward to northern Hudson Bay, January averages more than 20° below zero. The winters become less severe southward toward the United States-Canadian border and eastward to Labrador, Newfoundland and the Maritime Provinces. Mean temperatures above 60° prevail in summer in the interior of western and northwestern Canada and in eastern Canada south of Hudson Bay.

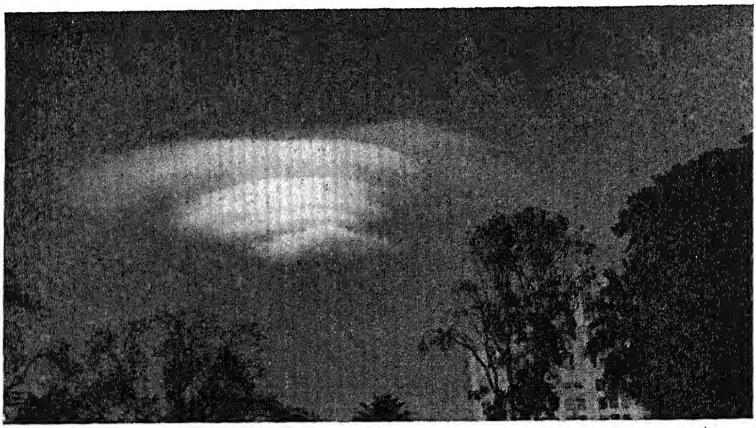


FIG. 52. A lenticular cloud in southern California.
(Courtesy L. H. Daingerfield)

Southeastern Canada, south of the Gulf of St. Lawrence averages 40° for the year and over 60° in summer. Rainfall averages 40 to 60 inches near the Atlantic but is 20 to 40 inches in Quebec and northern Ontario. Winters are fine but cold, and summers generally clear. Northeast of Hudson Bay the climate is severe.

The prairie provinces are relatively dry; the summers are short and the winters long and cold but there is much fine, clear weather at all seasons. In southern Alberta, as in parts of northwestern United States east of the Rockies, winter cold is often interrupted by "chinooks," westerly winds which have been robbed of their

moisture and become warm during descent to the plains. The temperature rises 20° to 40° in a few hours when the chinook blows. At other times cold waves and blizzards bring very severe conditions.

The Appendix contains records for Edmonton, Ft. Good Hope, Halifax, Hay River, Hebron, Montreal, Moose Factory, Port Nelson, St. John, and Vancouver. Included with the records of North America are Jacobshavn and Angmagsalik in Greenland and Stykkisholm in Iceland.

United States

Briefly, the climate of the United States depends upon its latitude, mostly in the belt of prevailing westerlies, but there are four other principal influences: (1) The north-south mountain ranges along the Pacific Coast, and the Rocky Mountains; (2) the north-south Appalachian Mountains separating the central valleys from the Atlantic on the east; (3) the great region of valleys and plains between the Rockies and Appalachians, open to the north and south; and (4) the Gulf of Mexico.

The Pacific coastal area has cool summers and mild winters, with small ranges of temperature, and has wet winters and dry summers. This is explained by the stabilizing influence of the Pacific Ocean and prevailing winds from ocean to land. In summer the winds are moist but become warmer and consequently drier on passing to the interior. This part of the country is like western Europe, and we can compare mean temperatures at Lisbon and San Diego, and at London and Seattle.

The mountains have the usual variations of temperature with elevation. The western slopes are wet, but the air becomes drier as it deposits its moisture on the mountains in passing eastward. On Pike's Peak (14,111 feet) January averages 2°, July 40°, and the total fall of rain (and melted snow) measures 40 inches in a year. Denver (5,272 feet) averages 30° in January, 72° in July and has 14 inches.

The Great Plains, central valleys and Gulf states depend on southerly and easterly winds for their moisture, and most of it

falls in summer. Winters are cold, relatively dry and subject to extremes of temperature. We find no city on other continents with a climate exactly like St. Louis, for example, with its cold winters, warm summers, great temperature extremes and rainfall as much as 40 inches in a year. Bucharest, Rumania, has mean temperatures and extremes much like St. Louis, but it is sheltered by mountains to the south and has only half as much rain. The northern interior of China has similar average temperatures and plenty of rain, mostly in summer, but it does not have the extremely low temperatures that occur in St. Louis. The mountains in the interior shield China from the intense cold of Siberia. In general, for the same reasons, all the plains, central valleys and the remainder of the vast area between the Appalachians and Rockies, exposed to cold dry winds from the north and warm moist winds from the south, have a climate which has no counterpart anywhere in the world.

FIG. 53. Altocumulus at Spokane, Washington. (J. A. Johnson)

The Appalachians are not high enough to offer a real barrier to the cold winds of the northern interior of the continent, and though the temperatures of China from Peking to Hong Kong are more like the United States from Maine to northern Florida than any other part of the world, the extremely low temperatures occasionally felt along our Atlantic seaboard are never recorded in eastern China.

When spring comes to this vast area, the temperature rises first in the south and then warmer weather spreads rapidly to the far north. The snow line retreats northward. Warm rains and "April showers" come with melting snow and there are floods in the rivers. In autumn, the temperature falls slowly; frost comes early in Canada and northern United States, but summer returns at intervals during the "harvest moon" and "hunter's moon"; as the harvest is finished, the population comes out to enjoy "Indian Summer." The sun sets with a red glow through the haze, and then the cold air masses of winter usher in another phase of this vigorously changing weather regime peculiar to North America.

For such comparison as is possible with weather in other parts of the world, the Appendix contains records for Abilene, Bismarck, Chicago, Denver, Galveston, Helena, Los Angeles, Miami, Nashville, New York, Norfolk, Phoenix, St. Louis and San Francisco.

Mexico

The climate of Mexico is essentially tropical and subtropical, but it has long coast lines on the Pacific Ocean and Gulf of Mexico, and a large plateau area about 5,000 feet in elevation. Both of these factors tend to eliminate the great extremes of temperature which otherwise might be found in a land area at that latitude. For these reasons it is customary to describe the climate of Mexico in three or four subdivisions: (a) hot lands at low elevations, (b) temperate, at 4,000 to 6,000 feet, (c) cool, at 6,000 to 9,000 feet; and also (d) frigid above 9,000 feet may be mentioned. In short, the temperature ranges from the oppressive heat of the tropical lowlands to the cold of heights permanently covered by snow. Rainfall is as varied as the topography, some sections having more

than 100 inches a year, while there are desert sections where no rain falls in some years. The best we can do in a brief summary is give examples.

At Progreso on the coast of Yucatan we have an example of the hot lowlands, with mean temperatures ranging from 72° in January to 80° in July, humidity high; it has a fairly dry winter and spring, and wet summer and autumn. April and May are the hottest months; frequently the temperature reaches 90° in late spring and drops below 60° in winter. The same general description applies to Vera Cruz, Tampico, and other places on the Gulf and Caribbean coasts.

Mazatlan is an example on the Pacific Coast of Mexico. The mean temperature is a degree or two below 70° in winter and as much above 80° in summer; the humidity is high; the temperature is frequently above 90° in summer and occasionally below 50° in winter; there is very little rain in winter and spring, while summer and early autumn are very wet.

Mexico City, at 7,411 feet elevation is representative of the high plateau with means of 54° in December and January, 65° in May and 64° in April and June. Winter is dry and summer has plenty of rain. The humidity is not high; nights are cool and days warm with a daily range of 20° or more during nearly the entire year. The temperature rarely reaches 90° and then only in May, the warmest month. Occasionally at night in winter the temperature goes below 32°.

The rainiest parts of Mexico are on the slopes facing the Pacific Ocean and Gulf of Mexico. The wettest place of record is Teapa in Tabasco with about 180 inches a year. The driest part is in the extreme northwest.

The outstanding features of the climate of Mexico are the "northers" of winter and tropical storms of the warm season. Northers prevail when cold air masses with high pressure occupy the Rocky Mountain and Great Plains region of the United States causing strong and cool north winds in southern Mexico and along the Gulf Coast, including Yucatan.

Hurricanes occasionally cross the Gulf and Caribbean coasts of Mexico in the months from June to November. On the Pacific side, an average of five tropical storms occur in a year during the months from June to November, but these occur most frequently in September.

The Appendix contains records in detail for Mazatlan, Mexico City, and Progreso.

APPENDIX

WEATHER RECORDS AROUND THE WORLD

IF WE try to recall in detail the weather of the last month in our home community, we realize that our recollections are vague. Yet we have a definite, though general, impression of normal or average weather. We can say with some assurance, for example, that the weather has been colder or drier than usual, which implies a knowledge of the average conditions at that particular season over a period of years. Professional meteorologists or climatologists keep many records for comparison and for computing normals or averages. But the records will give limited information unless we understand them.

When rows of figures are set down to show average weather conditions, they are likely to be considered rather dull. We may ask what is the difference if the average temperature is 66° or 78°? And what does it mean?

We find figures for temperature, let us say, which are the averages for London for a certain month. If we spend ten days in London during that month, our figures assume some importance. A dull figure in the table may be transformed into a reality as we experience a day in a dense fog off the Grand Banks, or in a cold gale in the North Sea, or in the heat of an African port. The traveler will find that there can be a vast difference even between temperatures of 66° and 78°.

Of course, we can take the advice of some person who has made the journey before, but that person may have experienced weather that was abnormally cold or warm, wet or dry, and the next season may be quite different. Even the native can scarcely be trusted. If the weather is bad, he is quite likely to say, "We never had weather like this before," when as a matter of fact it may not be uncommon at that particular time of year.

The Key Charts

Dots on the key charts (Figs. 54 and 55) show the locations of 110 cities for which weather data are given in this Appendix. Numbers alongside the dots refer to the names of the cities in the list which accompanies the charts. Supplementary records for a selected list of interior cities are also given in the Appendix. Combinations of letters and figures on the key charts show the locations of these places. If we wish to know what data are available for a given region, South Africa for example, we may note the numbers and combinations of letters and figures shown on that part of the map, and find the names in the lists. Knowing the names we can readily find them in the alphabetical lists in the tables in the Appendix. On the other hand, if we have the name of a city in mind, we can look directly in the Appendix for it; there we shall find its number or letter and figure combination which will be the key to its location on the chart. If the place we are interested in is not on the chart, we can look at the records of one or two nearby places.

The lists contain a representative selection of foreign places of interest. For comparative purposes, a selection of cities in the United States has been included.

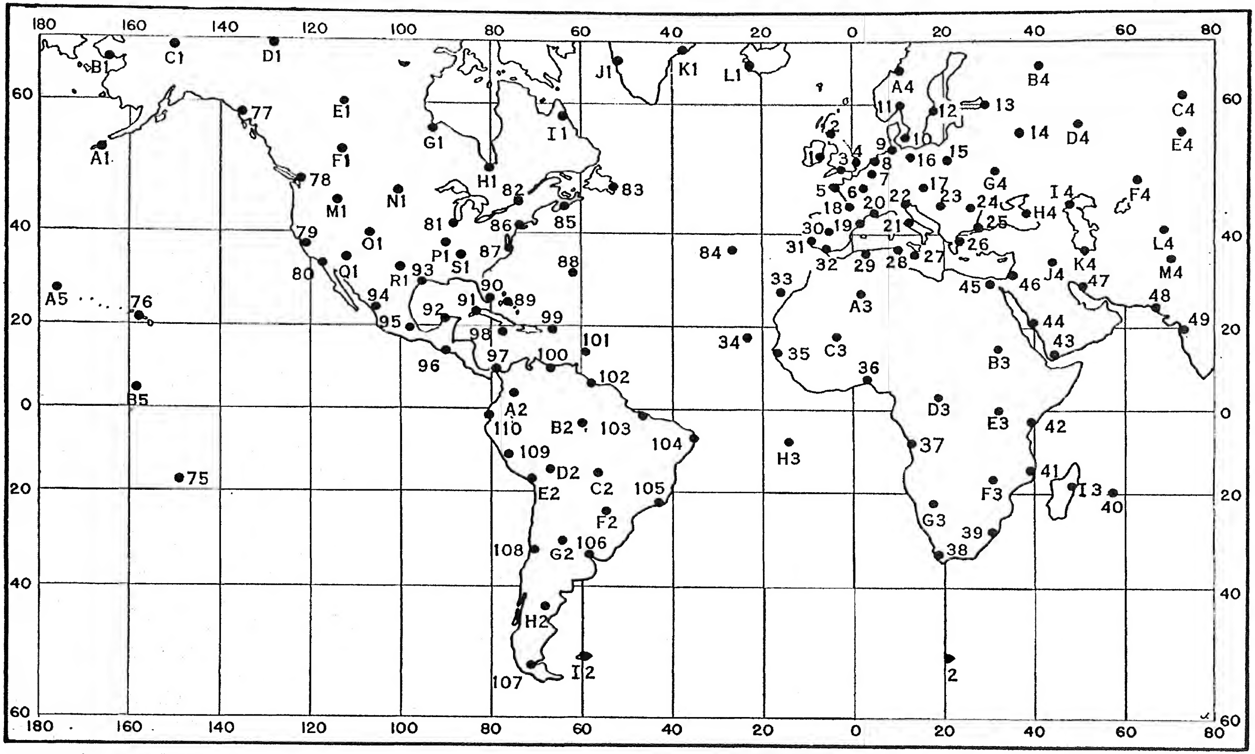


Fig. 54. Key chart showing locations of places for which weather records are given in the Appendix. Names which correspond to the numbers and letters on the chart are given on opposite page.

PLACES SHOWN ON KEY CHART, FIGURE 54

Appendix A—Tables I to IV

1. Dublin
2. Glasgow
3. Plymouth
4. London
5. Brest
6. Paris
7. Brussels
8. Amsterdam
9. Hamburg
10. Copenhagen
11. Oslo
12. Stockholm
13. Leningrad
4. Moscow
.5. Warsaw

16. Berlin
17. Vienna
18. Bordeaux
19. Barcelona
20. Marseilles
21. Rome
22. Venice
23. Belgrade
24. Bucharest
25. Constantinople
26. Athens
27. Malta
28. Tunis
29. Algiers
30. Madrid

31. Lisbon
32. Gibraltar
33. Canary Is.
34. St. Vincent
35. Bathurst
36. Lagos
37. Loanda
38. Capetown
39. Durban
40. Mauritius
41. Mozambique
42. Mombasa
43. Aden
44. Jidda
45. Cairo

46. Jerusalem
47. Bushire
48. Karachi
49. Bombay
75. Tahiti
76. Honolulu
77. Juneau
78. Vancouver
79. San Francisco
80. Los Angeles
81. Chicago
82. Montreal
83. St. Johns
84. Ponta Delgada
85. Halifax

86. New York
87. Norfolk
88. Bermuda
89. Nassau
90. Miami
91. Havana
92. Progreso
93. Galveston
94. Mazatlan
95. Mexico City
96. San Salvador
97. Cristobal
98. Kingston
99. San Juan
100. Caracas

101. Barbados
102. Georgetown
103. Para
104. Pernambuco
105. Rio de Janeiro
106. Buenos Aires
107. Punta Arenas
108. Valparaiso
109. Lima
110. Guayaquil

Appendix B—Table V

A1 Dutch Harbor
B1 Nome
C1 Tanana
D1 Fort Good Hope
E1 Hay River
F1 Edmonton
G1 Port Nelson
H1 Moose Factory
I1 Hebron
J1 Jacobshavn

K1 Angmagsalik
L1 Stykkisholm
M1 Helena
N1 Bismarck
O1 Denver
P1 St. Louis
Q1 Phoenix
R1 Abilene
S1 Nashville

A2 Bogota
B2 Manaos
C2 Cuyaba
D2 La Paz
E2 Arica
F2 Asuncion
G2 Cordoba
H2 Sarmiento
I2 Falkland Is.

A3 In Salah
B3 Khartoum
C3 Timbuctu
D3 New Antwerp
E3 Entebbe
F3 Salisbury
G3 Windhuk
H3 Ascension Is.
I3 Tamatave

A4 Trondheim
B4 Archangel
C4 Surgut
D4 Kasan
E4 Omsk
F4 Turgai
G4 Kiev
H4 Novorossiisk
I4 Astrakhan

J4 Baghdad
K4 Tehran
L4 Tashkent
M4 Peshawar

A5 Midway Is.
B5 Fanning Is.

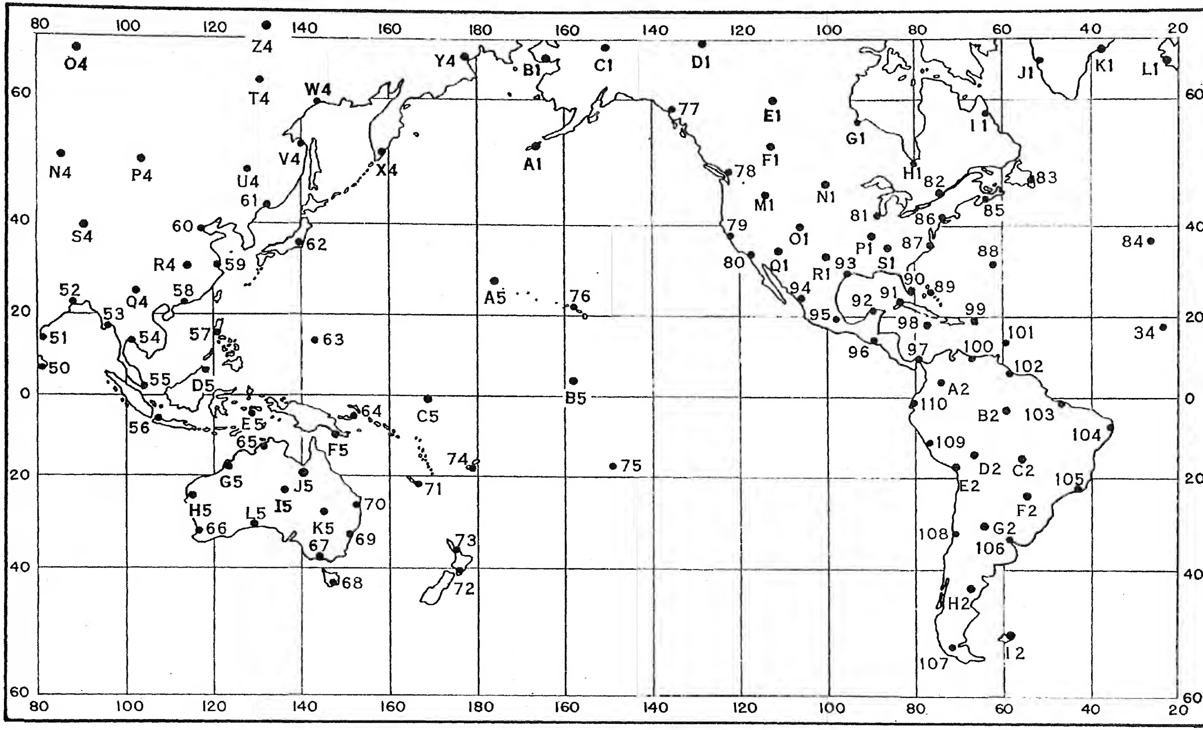


FIG. 55. Key chart showing locations of places for which weather records are given in the Appendix. Names which correspond to the numbers and letters are given on the opposite page.

PLACES SHOWN ON KEY CHART, FIGURE 55

Appendix A—Tables I to IV

34. St. Vincent
50. Colombo
51. Madras
52. Calcutta
53. Rangoon
54. Bangkok
55. Singapore
56. Batavia
57. Manila
58. Hong Kong
59. Shanghai
60. Tientsin
61. Vladivostok
62. Tokyo
63. Guam
64. Rabaul
65. Darwin
66. Perth
67. Melbourne
68. Hobart
69. Sydney
70. Brisbane
71. Numea
72. Wellington
73. Auckland
74. Suva
75. Tahiti
76. Honolulu
77. Juneau
78. Vancouver
79. San Francisco
80. Los Angeles
81. Chicago
82. Montreal
83. St. Johns
84. Ponta Delgada
85. Halifax
86. New York
87. Norfolk
88. Bermuda
89. Nassau
90. Miami
91. Havana
92. Progreso
93. Galveston
94. Mazatlan
95. Mexico City
96. San Salvador
97. Cristobal
98. Kingston
99. San Juan
100. Caracas
101. Barbados
102. Georgetown
103. Para
104. Pernambuco
105. Rio de Janeiro
106. Buenos Aires
107. Punta Arenas
108. Valparaiso
109. Lima
110. Guayaquil

Appendix B—Table V

NORTH AMERICA

A1 Dutch Harbor
B1 Nome
C1 Tanana
D1 Fort Good Hope
E1 Hay River
F1 Edmonton
G1 Port Nelson
H1 Moose Factory
I1 Hebron
J1 Jacobshavn
K1 Angmagsalik
L1 Stykkisholm
M1 Helena
N1 Bismarck
O1 Denver
P1 St. Louis
Q1 Phoenix
R1 Abilene
S1 Nashville

SOUTH AMERICA

A2 Bogota
B2 Manaos
C2 Cuyaba
D2 La Paz
E2 Arica
F2 Asuncion
G2 Cordoba
H2 Sarmiento
I2 Falkland Is.

ASIA

N4 Barnaul
O4 Turukhansk
P4 Irkutsk
Q4 Yunnanfu
R4 Hankow
S4 Luktchun
T4 Yakutsk
U4 Blagovyeshchensk
V4 Nikolaevsk
W4 Okhotsk
X4 Petropavlovsk
Y4 Novo Mariinsk
Z4 Verkhoyansk

AUSTRALIA AND PACIFIC

A5 Midway Is.
B5 Fanning Is.
C5 Ocean Is.
D5 Sandakan
E5 Amboina
F5 Port Moresby
G5 Broome
H5 Carnarvon
I5 Alice Springs
J5 Cloncurry
K5 Bourke
L5 Eucla

APPENDIX A

WEATHER RECORDS FOR 110 CITIES

(See key charts 54 and 55)

TABLE I

AVERAGE TEMPERATURE AND HUMIDITY

First line: Average daily high temperatures.
Second line: Average daily low temperatures.
Third line: Average humidity in percentage of saturation (100).
Numbers in parentheses after names of cities give their locations on the index charts, Figures 54 and 55.

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Aden (43)	80	81	84	89	93	95	93	92	93	90	85	81
	73	73	75	78	81	84	83	80	83	78	75	73
	70	70	70	66	67	64	63	64	67	64	66	68
Algiers (29)	59	60	63	66	71	76	81	82	79	73	66	61
	47	48	50	53	58	63	67	69	66	59	55	50
	65	65	65	65	65	65	68	70	69	67	67	68
Amsterdam (8)	41	42	47	54	62	68	70	70	65	57	47	42
	31	31	35	39	45	51	54	54	49	43	37	33
	89	87	84	78	75	75	77	80	83	87	89	91
Athens (26)	53	56	60	68	77	85	90	90	83	74	64	57
	42	42	46	51	60	67	72	72	66	60	52	46
	72	71	68	63	58	54	46	46	54	65	72	74
Auckland (73)	73	74	72	68	62	59	57	58	61	63	67	70
	59	60	58	55	51	48	46	47	49	51	54	57
	72	72	74	76	78	79	79	77	76	75	74	73
Bangkok (54)	92	93	95	97	95	93	92	92	91	91	89	89
	67	70	73	76	76	76	76	76	75	75	71	67
	68	60	63	62	65	69	68	66	73	74	68	67
Barbados (101)	83	83	84	85	87	87	86	86	86	86	85	84
	70	69	70	71	73	74	74	74	73	73	73	71
	68	66	66	64	64	69	70	71	71	72	72	71

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Barcelona (19)	55	57	60	64	70	78	82	83	78	71	62	57
	40	42	44	48	54	60	65	62	62	54	48	43
	70	69	69	69	68	67	66	68	70	70	71	70
Batavia (56)	83	83	85	86	87	86	86	87	87	87	87	85
	74	74	74	75	75	74	73	73	73	74	74	74
	87	87	86	85	84	83	81	78	78	79	82	85
Bathurst (35)	84	86	86	86	85	87	86	85	87	88	87	85
	64	64	66	67	69	73	73	73	73	74	72	66
	43	48	52	61	66	72	76	81	79	76	61	49
Belgrade (23)	39	42	55	63	74	78	84	84	78	63	50	40
	27	28	37	44	52	57	60	59	54	45	35	30
	80	74	69	65	66	69	62	58	60	78	75	81
Berlin (16)	35	38	45	54	65	72	74	72	66	55	44	37
	26	28	31	37	46	52	55	54	49	41	34	29
	86	83	78	69	65	65	68	70	75	82	85	87
Bermuda (88)	68	68	68	71	76	81	85	86	84	79	74	70
	58	57	57	59	64	69	73	74	72	69	63	60
	78	78	77	77	80	80	77	77	76	77	75	78
Bombay (49)	83	83	86	89	91	88	85	84	85	88	87	85
	68	69	73	77	81	80	78	77	77	77	74	70
	73	71	75	77	77	82	87	87	86	81	73	72
Bordeaux (18)	47	52	57	64	69	76	81	81	77	66	55	49
	36	36	40	46	49	56	60	59	56	48	42	37
	86	79	75	73	70	70	66	68	70	78	84	87
Brest (5)	49	50	53	58	63	68	71	72	69	61	55	50
	39	39	40	44	48	53	56	57	54	49	44	41
	88	85	82	82	80	82	83	82	84	86	88	88
Brisbane (70)	85	84	82	79	73	69	68	71	76	80	83	85
	69	68	66	62	55	51	48	50	55	60	64	67
	67	71	72	74	74	74	75	70	65	61	60	63
Brussels (7)	39	43	49	57	64	70	73	72	67	56	48	42
	30	33	35	40	46	52	55	55	52	44	38	33
	89	87	82	77	77	78	78	79	83	87	89	91
Bucharest (24)	33	41	51	63	74	80	85	85	76	64	48	39
	20	25	32	41	51	58	61	60	52	44	34	29
	84	79	72	59	58	60	54	53	60	71	78	86

1st line: ave. daily high temp.; 2nd: ave. daily low temp.; 3rd: ave. humidity

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Buenos Aires (106)	85	84	78	72	64	58	57	59	63	69	75	82
	63	62	59	53	46	41	42	43	46	50	55	60
	72	74	79	82	82	86	86	82	79	77	73	72
Bushire (47)	64	65	72	81	89	92	95	97	94	88	78	68
	51	53	59	67	76	81	84	84	79	71	62	55
	84	82	77	67	63	66	69	70	68	66	74	82
Cairo (45)	67	70	76	83	89	94	96	94	89	86	79	70
	45	47	51	56	62	67	70	71	67	63	56	49
	79	75	69	65	60	66	72	75	77	77	79	80
Calcutta (52)	77	82	91	95	95	91	89	88	88	87	82	77
	56	60	69	76	78	79	79	79	78	75	65	56
	85	82	80	79	79	85	88	89	87	85	82	81
Canary Is. (33)	71	71	71	71	73	75	77	79	79	78	75	72
	57	57	58	60	62	65	68	69	68	66	63	59
	72	73	72	72	72	73	75	75	74	74	74	72
Capetown (38)	80	80	78	72	67	63	62	63	66	70	74	77
	60	61	59	54	51	48	47	48	50	53	55	58
	66	68	69	74	76	79	80	79	76	71	67	64
Caracas (100)	75	77	78	80	80	78	77	78	79	79	77	75
	56	56	57	60	62	62	61	60	61	61	60	58
	80	76	76	76	78	81	81	81	81	82	84	82
Chicago (81)	31	33	43	55	66	76	81	79	73	62	47	35
	18	20	29	39	49	59	65	64	57	46	33	23
	74	73	70	67	65	67	65	68	69	68	70	75
Colombo (50)	87	88	89	89	88	86	86	85	86	86	86	86
	71	71	73	76	77	77	77	77	76	75	73	72
	74	72	73	76	79	80	80	78	78	80	79	75
Constantinople (25)	46	45	52	60	71	78	82	82	75	68	58	51
	38	36	40	46	55	62	67	68	62	57	49	43
	79	77	71	66	64	60	60	61	65	71	76	78
Copenhagen (10)	35	35	39	47	57	65	68	66	60	51	43	38
	29	29	31	37	45	53	56	56	51	44	37	34
	88	87	86	77	72	73	75	78	81	84	86	88
Cristobal (97)	83	83	84	85	85	85	84	84	85	85	83	84
	76	76	77	77	76	75	76	75	75	74	75	76
	81	80	79	81	85	87	87	87	86	86	87	84

1st line: ave. daily high temp.; 2nd: ave. daily low temp.; 3rd: ave. humidity

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Darwin (65)	90	90	91	93	91	88	87	89	92	94	94	92
	77	77	77	76	63	69	67	70	74	77	78	78
	75	77	72	62	55	54	51	53	57	59	62	69
Dublin (1)	46	47	49	53	58	64	66	65	62	55	50	47
	35	34	35	37	42	47	51	50	46	41	38	35
	87	86	85	82	81	81	82	83	85	86	87	87
Durban (39)	85	85	84	81	78	76	75	76	76	78	81	83
	68	68	66	63	58	54	54	56	59	61	64	66
	73	73	73	71	69	63	65	63	69	70	73	73
Galveston (93)	60	62	67	74	80	86	88	88	85	78	69	62
	49	51	57	64	71	77	79	78	75	68	58	51
	83	82	80	79	77	76	75	75	74	74	77	81
Georgetown (102)	84	83	84	85	85	85	85	86	87	87	86	84
	74	74	75	76	75	75	75	75	76	76	75	75
	72	73	66	67	77	76	73	69	65	64	69	74
Gibraltar (32)	61	62	63	67	72	78	82	83	79	72	66	62
	49	50	51	54	58	63	67	69	66	60	54	50
	77	77	77	75	73	71	72	72	75	77	79	78
Glasgow (2)	42	43	45	51	57	63	65	63	59	52	46	43
	35	35	36	39	43	48	51	51	48	42	38	35
	85	83	80	76	75	75	78	80	82	84	85	86
Guam (63)	84	84	85	87	88	88	86	86	86	86	85	84
	75	75	75	76	77	77	76	76	76	76	77	76
	79	78	78	76	76	78	83	84	84	84	82	80
Guayaquil (110)	83	82	82	83	82	81	80	81	82	81	83	85
	77	77	77	77	76	74	71	72	73	72	74	76
	80	82	82	79	77	78	79	77	76	74	75	72
Halifax (85)	32	32	38	48	59	68	74	74	68	57	45	35
	22	15	22	31	40	48	55	56	49	40	31	20
	88	86	82	78	79	81	86	87	87	86	85	86
Hamburg (9)	36	38	43	52	61	67	69	68	63	54	44	39
	28	30	33	39	46	53	56	56	51	44	36	32
	90	88	82	73	70	72	76	78	81	85	89	91
Havana (91)	79	79	81	84	86	88	89	89	88	85	81	80
	65	65	67	69	72	74	74	75	74	73	69	67
	75	73	71	71	74	77	75	76	78	78	75	75

1st line: ave. daily high temp.; 2nd: ave. daily low temp.; 3rd: ave. humidity

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Hobart (68)	71	71	68	63	57	53	52	55	59	63	66	69
	53	53	51	48	44	41	39	41	43	45	48	51
	56	60	61	67	71	76	75	70	64	61	57	55
Hong Kong (58)	64	63	67	75	81	85	87	87	85	81	74	67
	56	55	60	67	73	78	78	78	77	73	65	58
	73	76	83	85	83	83	82	83	77	71	66	67
Honolulu (76)	76	76	77	78	80	82	83	84	83	82	80	78
	66	66	66	68	69	72	73	73	73	72	70	68
	70	70	68	67	67	66	65	65	65	67	69	70
Jerusalem (46)	51	55	62	70	78	84	87	88	85	80	66	56
	38	41	45	51	56	62	65	64	62	59	50	43
	75	71	56	49	43	46	49	52	58	60	67	76
Jidda (44)	77	77	82	85	88	91	92	93	91	89	85	81
	68	67	71	75	77	79	82	83	81	78	75	71
	67	65	68	68	68	69	67	70	75	74	70	68
Juneau (77)	32	35	39	47	56	62	64	62	56	48	40	34
	24	26	29	34	40	46	50	49	44	38	31	27
	78	76	71	70	70	70	79	82	82	82	78	77
Karachi (48)	76	78	82	85	89	91	88	85	86	88	85	78
	58	61	68	74	79	83	81	78	77	73	67	59
	56	59	67	77	81	81	82	84	81	70	58	54
Kingston (98)	86	86	86	87	87	89	90	90	89	88	87	87
	67	67	68	70	72	74	73	73	73	73	71	69
	78	78	77	78	79	78	76	79	82	84	82	80
Lagos (36)	88	89	90	89	88	85	83	83	84	85	88	89
	74	76	77	77	76	74	73	73	74	74	75	75
	74	74	73	75	76	81	82	79	79	78	76	76
Leningrad (13)	23	24	33	45	58	66	71	66	57	45	34	26
	12	12	18	31	42	51	57	53	45	37	27	18
	87	85	79	71	64	63	68	74	78	81	86	87
Lima (109)	81	83	84	80	76	70	67	67	69	69	74	79
	63	65	64	62	58	57	56	56	56	57	60	63
	78	77	77	78	83	85	85	84	84	81	80	79
Lisbon (31)	54	56	59	63	66	77	75	76	73	68	61	58
	46	47	51	54	58	63	65	67	64	58	53	47
	78	75	71	69	67	64	62	61	66	71	77	79

1st line: ave. daily high temp.; 2nd: ave. daily low temp.; 3rd: ave. humidity

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Loanda (37)	82	83	84	84	81	76	73	73	75	78	81	81
	73	75	75	75	72	67	64	64	67	71	73	73
	79	78	79	82	82	82	82	83	82	81	81	81
London (4)	43	45	49	55	62	68	71	70	65	56	49	45
	35	35	36	40	45	51	54	54	49	44	39	36
	85	82	79	75	73	73	73	76	80	85	86	86
Los Angeles (80)	65	66	67	70	72	76	81	82	80	76	73	67
	46	47	49	51	53	57	60	61	59	55	51	48
	57	62	62	65	68	69	67	66	65	62	52	54
Madras (51)	85	87	90	93	99	99	96	94	93	89	85	83
	68	69	72	77	81	81	79	78	77	75	73	70
	84	83	79	75	66	62	70	75	78	83	84	83
Madrid (30)	48	52	57	63	72	79	86	87	76	65	54	48
	33	35	38	42	50	56	61	62	55	47	40	35
	80	72	65	61	60	50	40	42	56	69	78	81
Malta (27)	59	60	62	66	71	79	84	85	81	76	68	62
	51	51	52	56	61	67	72	73	71	66	59	54
	77	77	75	75	73	70	66	68	71	73	75	78
Manila (57)	80	81	84	87	88	87	85	85	83	84	82	81
	70	71	75	75	76	76	74	75	76	75	72	71
	79	74	71	69	75	80	85	85	86	85	83	82
Marseilles (20)	52	55	59	65	72	78	83	82	77	67	59	53
	37	38	41	45	51	57	61	60	56	50	43	38
	68	64	62	60	59	57	54	57	63	69	70	70
Mauritius (40)	86	85	84	82	79	76	75	75	77	81	84	86
	73	73	72	70	66	63	61	61	63	65	67	71
	76	79	80	79	78	76	75	74	72	70	69	72
Mazatlan (94)	73	74	75	78	83	87	88	88	88	86	81	77
	60	61	62	65	70	75	76	75	76	74	67	63
	76	76	77	78	77	75	78	79	80	77	75	75
Melbourne (67)	78	78	74	68	61	57	55	59	63	67	71	75
	57	57	55	51	47	44	42	43	46	48	51	54
	60	61	65	70	76	77	78	72	68	66	63	60
Mexico City (95)	66	70	75	78	79	76	74	74	72	70	68	65
	42	44	48	52	54	55	54	54	54	50	48	43
	53	48	45	45	51	62	67	68	70	65	61	58

1st line: ave. daily high temp.; 2nd: ave. daily low temp.; 3rd: ave. humidity

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Miami (90)	75	75	77	80	83	85	87	87	86	83	78	75
	62	61	64	68	72	75	76	76	76	73	66	63
	74	72	70	69	72	74	73	73	75	75	71	73
Mombasa (42)	85	86	87	85	82	81	79	80	82	83	84	85
	74	75	76	75	73	71	70	70	70	73	74	74
	74	73	73	81	83	81	82	80	78	78	76	74
Montreal (82)	26	25	33	42	56	66	73	72	65	54	42	31
	9	4	19	29	39	49	57	57	50	41	31	18
	87	86	84	82	76	77	80	81	82	82	84	86
Moscow (14)	14	19	29	43	60	67	71	68	56	44	28	17
	5	8	15	29	42	50	54	51	42	33	21	10
	85	82	78	76	68	73	74	79	81	84	88	87
Mozambique (41)	90	89	90	88	85	82	81	82	85	88	91	92
	74	74	74	72	67	64	63	63	65	69	73	75
	79	80	80	78	76	76	75	74	72	71	69	73
Nassau (89)	76	77	78	80	83	86	88	88	87	85	80	78
	67	67	68	69	72	75	76	76	76	75	71	69
	76	74	71	71	73	73	72	72	73	74	74	75
New York (86)	37	38	45	57	68	77	82	80	74	64	51	41
	24	24	30	42	53	60	66	66	60	49	37	29
	67	65	63	62	63	66	67	70	70	67	68	67
Norfolk (87)	50	50	57	66	75	83	87	85	80	70	59	51
	34	34	40	48	58	66	70	70	65	55	44	36
	72	70	67	65	64	69	72	73	73	70	69	71
Numea (71)	86	86	85	83	79	77	77	76	78	80	83	85
	73	74	73	71	67	65	62	62	63	65	69	71
	71	74	75	76	76	74	73	69	68	64	68	69
Oslo (11)	28	30	38	48	59	65	71	66	59	46	36	29
	21	21	26	34	43	50	56	53	46	37	30	24
	82	79	74	67	64	64	69	75	80	82	83	84
Para (103)	87	86	87	87	88	88	88	88	89	89	90	89
	72	72	73	73	73	72	71	71	71	71	71	72
	92	94	93	93	91	89	89	89	87	87	88	91
Paris (6)	42	46	52	60	67	72	76	75	69	60	49	44
	32	33	36	40	46	52	55	54	50	44	37	35
	86	81	76	69	71	73	73	74	79	85	87	88

1st line: ave. daily high temp.; 2nd: ave. daily low temp.; 3rd: ave. humidity

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Pernambuco (104)	87	87	87	86	84	82	81	81	83	85	86	86
	77	77	77	76	74	73	72	72	74	75	76	77
	72	72	74	75	77	77	77	76	72	71	71	72
Perth (66)	85	85	81	76	69	64	63	64	66	69	75	81
	63	63	61	57	53	50	48	48	50	53	57	61
	49	49	51	56	65	71	71	67	73	59	53	50
Plymouth (3)	47	47	50	55	60	65	67	67	64	57	52	49
	38	38	38	42	47	52	55	55	52	46	42	40
	88	86	84	78	77	80	78	80	80	85	86	88
Ponta Delgada (84)	62	61	62	63	66	71	75	77	75	70	66	63
(Azores)	55	54	54	56	58	62	66	68	66	62	59	57
	77	76	73	74	75	75	74	74	74	75	77	77
Progreso (92)	77	78	81	84	86	85	85	85	84	82	78	78
	67	66	69	71	74	75	75	75	75	75	71	68
	78	77	78	77	79	82	83	85	84	78	78	79
Punta Arenas (107)	59	58	55	49	43	40	38	40	45	50	54	57
	45	44	43	39	35	33	33	33	35	38	40	43
	64	65	69	72	76	76	76	72	69	64	62	63
Rabaul (64)	90	90	90	90	91	90	89	89	91	92	91	90
	73	73	73	73	73	73	72	72	73	73	73	73
	76	75	76	77	75	75	73	71	68	69	71	76
Rangoon (53)	89	92	96	98	92	86	85	85	86	88	87	87
	65	67	71	76	77	76	76	76	76	76	73	67
	82	84	85	80	86	91	92	93	92	90	86	82
Rio de Janeiro (105)	82	83	81	78	75	74	73	73	74	75	78	81
	74	76	75	73	69	67	65	66	66	69	71	73
	78	78	79	79	79	78	78	76	79	79	78	78
Rome (21)	52	55	59	66	73	81	87	86	80	70	60	53
	38	40	44	49	54	61	66	65	61	54	46	40
	72	69	66	65	61	58	53	55	62	70	73	74
St. Johns (83)	31	29	34	41	51	61	68	68	61	52	43	35
	16	15	21	29	35	42	50	52	46	39	31	23
	79	79	82	81	78	75	76	75	77	79	83	80
St. Vincent (34)	75	76	76	77	77	79	82	84	85	84	82	78
	67	66	67	67	68	70	71	74	75	74	72	69
	69	69	66	69	71	72	72	76	75	73	69	69

1st line: ave. daily high temp.; 2nd: ave. daily low temp.; 3rd: ave. humidity

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
San Francisco (79)	55	58	61	62	63	66	65	65	68	68	63	56
	45	47	48	49	51	52	53	53	55	54	51	46
	75	72	70	70	72	74	78	80	74	70	70	74
San Juan (99)	80	80	81	82	84	85	85	85	86	86	84	81
	70	69	70	71	73	74	75	75	75	74	73	71
	78	77	75	76	77	78	79	78	79	79	79	79
San Salvador (96)	86	89	90	90	87	86	86	86	85	85	84	85
	59	60	61	64	65	65	65	65	65	64	62	60
	69	68	68	70	80	85	82	82	85	79	77	72
Shanghai (59)	46	47	55	66	77	82	90	90	82	74	63	53
	33	34	40	50	59	67	74	74	66	57	45	36
	79	79	79	80	80	84	84	84	83	80	78	76
Singapore (55)	86	88	89	89	89	88	88	88	88	88	87	86
	73	73	74	75	75	75	75	75	75	74	74	73
	82	79	78	80	79	79	78	78	78	79	81	83
Stockholm (12)	31	32	36	46	57	67	71	67	59	48	39	33
	22	21	24	31	40	49	54	52	46	38	31	24
	85	83	78	71	63	62	67	73	78	82	85	87
Suva (74)	86	86	86	84	82	80	79	79	80	81	83	85
	74	74	74	73	71	69	68	68	69	70	71	73
	78	80	81	81	82	81	80	80	78	76	76	77
Sydney (69)	78	78	76	71	65	61	59	63	67	71	74	77
	65	65	63	58	52	48	46	47	51	56	60	63
	71	74	72	72	72	70	69	60	64	64	68	70
Tahiti (75)	88	88	87	87	85	84	84	84	86	87	87	87
	74	75	75	74	72	70	68	68	71	71	71	72
	77	78	81	80	80	81	78	78	75	73	78	79
Tientsin (60)	33	39	51	68	80	87	90	87	79	68	49	36
	16	20	31	45	56	66	73	72	62	49	32	20
	62	58	55	51	54	63	75	76	69	65	62	58
Tokyo (62)	47	47	53	63	70	76	83	85	79	69	60	51
	30	31	36	47	54	63	69	72	66	54	43	33
	64	62	67	73	76	82	83	82	83	80	74	66
Tunis (28)	58	61	66	70	77	85	92	93	86	78	69	61
	43	43	46	50	56	63	67	67	64	57	50	44
	76	75	72	69	65	59	55	59	65	72	74	76

1st line: ave. daily high temp.; 2nd: ave. daily low temp.; 3rd: ave. humidity

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Valparaiso (108)	73	73	71	68	64	61	60	62	63	66	69	72
	56	56	54	52	50	47	47	47	48	50	52	54
	69	70	73	75	77	76	77	75	74	73	67	67
Vancouver (78)	40	43	49	56	62	68	73	72	64	55	47	42
	31	33	36	39	45	50	55	53	48	43	38	34
	87	86	78	73	73	73	73	77	83	89	91	90
Venice (22)	41	46	52	60	70	77	82	81	73	63	51	44
	32	36	42	49	58	64	68	67	60	52	42	36
	80	78	75	73	70	68	65	67	72	77	79	79
Vienna (17)	36	38	48	56	65	70	73	72	65	55	42	38
	28	29	35	41	50	55	58	57	51	43	35	31
	79	78	73	67	69	69	69	71	76	81	83	83
Vladivostok (61)	13	23	33	46	54	63	70	76	68	55	36	20
	0	6	19	34	43	52	60	64	55	42	24	8
	67	68	70	71	77	86	89	86	79	68	65	66
Warsaw (15)	30	32	41	54	67	72	75	73	65	54	40	32
	21	23	28	38	48	53	56	55	48	41	32	25
	87	85	81	75	70	71	73	75	79	85	88	89
Wellington (72)	70	69	67	63	58	55	53	54	57	60	63	67
	56	56	55	51	47	45	42	43	46	48	51	54
	72	73	73	75	77	79	78	77	75	75	75	73

1st line: ave. daily high temp.; 2nd: ave. daily low temp.; 3rd: ave. humidity

TABLE II

Extremes of Temperature

First line: Highest temperature of record for each month.
Second line: Lowest temperature of record for each month.
Numbers in parentheses after names of cities give their locations on the index charts, Figures 54 and 55.

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Aden (43)	86	89	95	101	102	102	102	100	99	100	94	88
	65	65	67	69	70	76	70	70	72	70	68	67
Algiers (29)	82	87	88	95	102	109	112	112	110	103	92	84
	28	33	33	40	44	55	61	63	52	44	35	28

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Amsterdam (8)	54	60	66	75	83	89	89	89	84	74	64	55
	8	9	20	26	36	45	48	49	41	30	22	11
Athens (26)	75	74	83	91	101	105	105	107	103	95	87	71
	20	21	20	35	42	54	58	59	48	39	30	24
Auckland (73)	90	90	88	89	78	70	75	74	74	79	83	90
	46	46	44	39	32	33	32	32	34	36	36	43
Bangkok (54)	100	106	103	106	106	100	101	99	98	100	99	100
	54	56	62	68	71	70	71	72	70	64	56	52
Barbados (101)	86	87	88	90	90	89	89	89	90	89	89	88
	61	61	62	64	66	67	69	68	67	68	67	64
Barcelona (19)	78	75	79	81	84	93	99	97	94	88	78	73
	15	25	25	29	39	46	48	48	41	33	23	25
Batavia (56)	92	91	92	92	92	91	90	92	96	95	96	92
	69	69	69	70	70	67	67	67	66	69	68	67
Bathurst (35)	100	101	105	105	103	103	99	93	96	96	97	96
	55	57	58	59	60	60	65	62	63	66	59	50
Belgrade (23)	64	69	80	86	92	94	100	107	95	86	72	64
	1	–9	12	28	35	43	48	45	36	9	12	2
Berlin (16)	57	62	73	83	96	95	99	97	91	79	66	58
	–13	–15	7	20	27	35	43	41	32	19	3	–3
Bermuda (88)	81	81	84	87	88	92	98	99	98	92	87	81
	41	40	41	42	49	58	62	62	59	53	49	45
Bombay (49)	92	95	97	100	96	99	99	88	91	95	96	91
	56	56	62	68	73	73	73	72	71	70	64	56
Bordeaux (18)	67	73	78	84	91	96	103	107	98	86	75	67
	3	17	16	29	35	41	47	47	38	27	16	16
Brest (5)	61	68	75	83	87	91	92	95	89	83	72	60
	12	16	23	31	33	41	43	41	38	30	18	19
Brisbane (70)	109	102	99	95	89	89	83	87	95	101	106	106
	59	59	52	49	41	36	36	37	41	43	49	56
Brussels (7)	57	66	71	80	91	94	96	97	92	80	68	60
	–4	–1	9	23	29	35	40	42	35	24	9	3
Bucharest (24)	58	72	82	91	96	105	105	105	97	92	80	69
	–23	–9	–2	21	30	40	46	44	29	21	–2	–11

1st line: highest temp. of record; 2nd: lowest temp. of record

EXTREMES OF TEMPERATURE

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Buenos Aires (106)	102	103	95	97	84	77	84	87	86	91	95	102
	43	40	38	33	25	23	22	27	28	28	36	39
Bushire (47)	80	85	105	103	107	112	112	115	107	101	92	87
	32	37	45	47	58	69	74	73	68	55	42	37
Cairo (45)	85	89	100	108	112	113	106	106	106	102	97	83
	31	38	39	47	50	58	62	66	58	54	45	38
Calcutta (52)	88	98	103	107	107	108	98	94	95	94	91	85
	44	46	50	61	65	70	68	74	72	63	51	45
Canary Is. (33)	86	84	85	90	86	89	90	99	96	95	88	85
	46	47	47	50	54	58	62	62	59	56	52	47
Capetown (38)	103	103	101	99	92	86	81	91	92	99	101	104
	48	45	43	38	35	33	32	32	35	37	42	45
Caracas (100)	83	88	91	89	89	86	84	86	85	86	84	83
	47	46	45	51	52	53	52	53	53	54	51	47
Chicago (81)	65	68	81	90	98	102	105	102	98	87	77	68
	–20	–21	–12	17	27	40	50	47	32	14	–2	–23
Colombo (50)	94	97	97	95	93	91	89	90	91	91	92	92
	62	62	65	69	69	71	70	70	71	68	64	63
Constantinople (25)	65	71	78	83	90	94	100	99	95	89	80	69
	17	19	18	32	39	49	55	52	42	39	35	20
Copenhagen (10)	49	51	60	72	80	85	85	81	80	71	57	54
	–3	0	7	22	29	40	46	44	36	25	14	11
Cristobal (97)	83	88	89	93	93	92	90	90	92	91	91	89
	70	71	67	72	71	68	70	71	70	70	69	66
Darwin (65)	100	101	102	104	102	98	98	98	102	105	103	102
	68	69	68	66	60	56	56	58	63	69	69	70
Dublin (1)	62	65	66	69	80	82	85	85	82	73	67	60
	4	8	16	19	27	31	35	33	29	22	15	7
Durban (39)	105	99	97	98	91	93	94	103	111	108	105	102
	56	56	52	50	41	43	42	46	47	48	52	55
Galveston (93)	76	83	85	86	93	99	101	100	96	91	85	80
	11	8	30	41	52	57	66	67	54	41	26	18
Georgetown (102)	88	89	89	89	89	88	89	90	91	92	91	89
	68	69	71	71	70	69	71	71	69	71	69	70

1st line: highest temp. of record; 2nd: lowest temp. of record

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Gibraltar (32)	75	81	78	87	89	97	100	100	95	95	79	77
	33	33	37	43	46	49	55	57	50	44	35	30
Glasgow (2)	55	56	62	71	78	85	85	84	83	71	60	56
	8	7	19	21	29	36	41	35	31	24	12	8
Guam (63)	89	89	90	92	94	94	92	91	91	91	90	92
	68	67	68	71	71	72	70	71	70	69	69	70
Guayaquil (110)	88	89	88	88	86	84	88	88	86	86	89	88
	73	75	74	74	69	66	66	67	69	68	70	72
Halifax (85)	55	50	70	82	90	94	99	94	88	88	67	62
	–17	–21	–10	7	22	26	33	39	29	18	7	–14
Hamburg (9)	56	59	68	75	89	88	90	89	84	73	63	53
	–1	2	10	23	30	41	46	42	34	26	8	–4
Havana (91)	89	91	91	94	94	95	93	95	94	94	91	89
	50	50	53	55	59	66	66	68	67	63	55	51
Hobart (68)	105	104	99	90	78	75	72	81	80	92	98	105
	40	39	36	30	29	28	27	30	30	32	35	38
Hong Kong (58)	79	79	82	89	91	94	94	97	94	94	86	82
	32	38	46	52	60	69	72	72	66	57	47	41
Honolulu (76)	84	84	84	86	87	88	88	88	88	90	86	85
	54	52	53	59	60	63	63	63	65	63	59	55
Jerusalem (46)	66	78	92	95	97	108	106	105	101	96	86	76
	28	28	28	30	38	48	51	52	50	42	34	25
Jidda (44)	91	94	98	100	107	115	103	100	112	100	95	89
	55	56	59	63	63	71	72	74	66	72	65	61
Juneau (77)	52	53	61	69	80	87	89	87	77	66	64	60
	–15	–15	–5	13	24	31	38	36	29	13	–1	–10
Karachi (48)	89	93	106	111	118	114	110	99	106	108	100	91
	40	43	47	57	65	68	73	73	69	57	48	39
Kingston (98)	93	92	93	93	94	95	96	97	96	96	96	96
	57	59	58	63	66	68	66	68	68	65	52	57
Lagos (36)	95	96	99	99	104	93	93	96	94	96	99	99
	63	66	60	69	69	69	68	67	68	69	70	66
Leningrad (13)	43	42	56	71	86	91	90	90	77	67	53	45
	–28	–30	–19	2	22	33	43	37	29	9	–8	–29

1st line: highest temp. of record; 2nd: lowest temp. of record

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Lima (109)	88	90	91	88	82	77	81	75	79	76	79	86
	59	59	61	58	53	49	49	51	50	53	53	56
Lisbon (31)	66	77	83	87	94	99	103	100	99	89	77	66
	30	29	24	40	42	49	52	55	51	43	34	31
Loanda (37)	95	93	99	91	94	86	81	80	81	84	93	88
	67	68	67	68	63	57	56	57	58	62	67	66
London (4)	57	62	68	80	87	88	90	94	92	83	63	58
	9	11	17	26	30	37	43	41	31	25	20	11
Los Angeles (80)	90	92	99	100	103	105	109	106	108	102	96	89
	28	28	31	36	40	46	49	49	44	40	34	30
Madras (51)	93	96	102	109	113	110	106	104	102	103	95	95
	57	59	62	69	70	69	71	69	69	62	59	57
Madrid (30)	64	73	84	93	96	105	112	109	103	91	78	66
	11	14	17	26	30	38	45	44	36	24	10	11
Malta (27)	76	73	83	93	89	99	104	105	100	94	82	75
	39	34	37	44	49	58	62	62	57	45	42	39
Manila (57)	93	96	97	100	101	100	97	94	95	95	93	92
	58	60	61	63	68	71	71	70	70	67	62	61
Marseilles (20)	69	71	79	83	93	94	100	101	92	86	76	70
	14	18	20	30	32	41	47	47	41	27	21	11
Mauritius (40)	95	91	90	87	85	83	80	80	83	88	91	95
	65	64	63	61	55	51	51	51	51	55	57	62
Mazatlan (94)	83	86	84	89	90	95	93	95	93	92	90	87
	47	49	51	49	56	66	65	66	63	61	50	42
Melbourne (67)	111	109	105	94	84	72	68	77	85	98	106	111
	42	40	37	35	30	28	27	28	31	32	37	40
Mexico City (95)	77	81	85	89	94	87	87	84	80	80	80	76
	27	29	32	38	42	43	46	47	43	36	30	29
Miami (90)	85	88	92	93	94	94	96	96	95	93	88	91
	29	27	34	45	50	61	66	67	62	52	36	30
Mombasa (42)	91	93	93	91	90	89	83	84	90	90	90	90
	70	70	71	69	67	61	65	64	64	64	69	69
Montreal (82)	52	48	58	74	81	87	91	92	87	82	63	53
	–27	–23	–16	2	22	32	37	42	34	26	3	–18

1st line: highest temp. of record; 2nd: lowest temp. of record

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Moscow (14)	43	43	64	78	95	93	97	100	89	72	57	46
	–44	–37	–25	–11	20	35	43	36	20	4	–25	–42
Mozambique (41)	100	97	95	93	91	88	87	92	93	95	100	101
	72	69	67	64	60	55	55	56	59	62	67	70
Nassau (89)	85	85	86	90	90	92	93	94	92	92	89	85
	51	54	55	58	65	63	67	67	65	65	56	53
New York (86)	68	73	80	91	95	97	102	102	100	88	74	68
	–6	–14	3	12	34	44	54	51	39	27	7	–13
Norfolk (87)	80	82	92	95	98	102	102	105	100	91	82	76
	5	2	14	23	38	49	57	56	40	31	17	5
Numea (71)	95	93	94	96	85	84	87	83	90	93	94	93
	65	67	67	62	59	59	57	54	57	58	60	64
Oslo (11)	54	59	64	77	86	93	95	91	78	74	58	55
	–12	–13	–6	3	25	33	40	36	25	7	0	–26
Para (103)	95	94	95	95	94	93	94	95	96	98	97	97
	66	68	66	69	68	68	64	67	65	67	67	66
Paris (6)	60	69	79	85	92	96	101	99	96	83	71	64
	1	4	12	26	29	36	42	41	33	22	5	–14
Pernambuco (104)	94	93	94	93	90	89	87	88	90	91	91	92
	71	71	71	69	68	68	64	66	67	69	70	70
Perth (66)	108	107	106	100	90	82	76	81	91	93	105	108
	50	48	46	39	34	35	34	35	39	41	42	48
Plymouth (3)	59	58	65	73	77	85	85	83	84	78	62	62
	17	19	22	28	33	37	42	42	36	30	25	23
Ponta Delgada (84)	67	66	69	70	73	78	81	82	82	79	73	69
(Azores)	43	42	44	44	49	52	58	60	57	50	47	43
Progreso (92)	88	92	97	101	102	98	94	92	91	94	92	90
	53	53	55	58	64	70	69	69	70	67	62	56
Punta Arenas (107)	86	79	75	69	63	52	53	55	61	67	76	75
	26	28	24	23	16	11	12	15	19	25	23	23
Rabaul (64)	95	95	95	95	94	94	94	97	99	99	97	99
	69	69	68	67	69	67	66	65	67	67	68	69
Rangoon (53)	98	100	104	106	107	98	93	92	94	94	94	98
	55	56	61	68	71	71	72	68	72	70	61	57

1st line: highest temp. of record; 2nd: lowest temp. of record

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Rio de Janeiro (105)	99	98	97	93	95	88	88	93	100	97	99	102
	62	63	63	60	56	52	54	53	50	57	59	62
Rome (21)	65	69	77	86	90	97	104	103	94	90	76	70
	21	21	25	33	36	48	53	52	45	35	28	22
St. Johns (83)	59	56	63	72	81	87	90	92	84	75	66	60
	–19	–21	–10	–1	20	27	34	32	29	22	6	–4
St. Vincent (34)	85	85	89	88	83	86	92	92	96	93	90	90
	35	35	39	31	26	23	28	25	37	29	31	34
San Francisco (79)	78	80	86	89	97	100	99	92	101	96	83	74
	29	33	33	40	42	46	47	46	47	43	38	27
San Juan (99)	87	90	90	93	94	93	91	93	94	94	93	88
	63	62	63	65	66	66	70	68	69	68	66	62
San Salvador (96)	101	103	103	103	103	97	96	98	100	101	102	102
	45	51	54	54	58	61	61	60	60	58	52	50
Shanghai (59)	74	78	82	93	96	100	102	103	100	90	86	73
	10	17	22	30	37	51	61	61	44	34	24	14
Singapore (55)	93	94	94	95	97	95	93	92	93	93	92	93
	67	66	67	70	70	71	70	69	70	69	69	69
Stockholm (12)	51	54	59	73	84	91	92	88	77	66	57	52
	–22	–12	–9	6	24	32	35	38	29	16	0	–9
Suva (74)	95	97	98	94	93	90	90	90	90	93	93	97
	67	67	66	61	61	58	55	57	57	57	55	62
Sydney (69)	109	102	103	91	86	80	75	82	92	100	103	107
	51	49	49	45	40	38	36	37	41	42	46	48
Tahiti (75)	92	92	93	92	90	90	89	88	91	91	93	93
	68	68	67	66	64	64	61	64	68	63	64	64
Tientsin (60)	54	64	77	96	106	107	109	103	91	88	78	56
	–2	–1	13	27	38	49	62	57	41	33	10	–2
Tokyo (62)	72	69	74	83	85	93	98	96	95	90	77	74
	17	18	22	30	36	47	55	60	51	36	26	20
Tunis (28)	84	83	91	104	103	108	118	117	112	105	90	81
	31	32	34	37	37	48	50	52	52	40	33	30
Valparaiso (108)	86	94	89	87	78	76	80	78	79	88	91	91
	50	50	46	44	39	36	36	39	39	44	45	49

1st line: highest temp. of record; 2nd: lowest temp. of record

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Vancouver (78)	56	58	65	79	82	85	90	92	82	73	63	57
	2	13	15	27	33	36	43	39	30	23	10	11
Venice (22)	56	62	73	77	86	91	97	95	89	77	69	61
	14	20	24	36	42	50	54	50	38	28	23	18
Vienna (17)	59	67	75	79	86	92	96	97	88	80	68	63
	–8	2	3	18	31	43	48	45	31	16	6	–4
Vladivostok (61)	39	46	57	69	80	84	96	92	84	74	63	50
	–22	–20	–7	17	31	39	47	50	39	17	0	–15
Warsaw (15)	51	54	69	78	93	96	96	98	88	77	60	57
	–22	–28	–14	22	30	35	43	41	29	15	0	–5
Wellington (72)	85	88	81	74	71	69	66	69	69	76	81	83
	42	42	40	36	33	31	30	29	33	34	38	41

1st line: highest temp. of record; 2nd: lowest temp. of record

TABLE III

Rainy Days and Cloudiness

First line: Average number of days each month with rain. This includes days with snow if there is a sufficient quantity to measure when melted (usually 0.01 inch or more). An asterisk indicates an average of less than one day.
Second line: Average cloudiness for each month; the number is the percentage of sky covered by clouds.
Numbers in parentheses after names of cities give their locations on the index charts, Figures 54 and 55.

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Aden (43)	1	*	1	1	*	*	0	*	*	*	*	*
	59	59	49	36	33	32	34	37	39	23	33	47
Algiers (29)	15	13	13	11	9	5	2	2	7	10	13	15
	51	48	48	47	43	33	29	28	40	46	52	51
Amsterdam (8)	10	8	11	8	9	9	11	11	10	13	11	13
	71	67	66	60	58	60	60	62	58	63	70	75
Athens (26)	12	11	11	9	7	4	3	3	4	9	12	13
	60	60	50	50	40	20	10	10	20	40	60	60
Auckland (73)	10	10	11	13	19	20	21	19	17	17	15	10
	60	60	50	60	60	60	60	60	60	60	60	60
Bangkok (54)	1	3	4	6	17	18	19	19	21	17	7	3
	20	27	30	38	57	58	63	59	69	56	32	19

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Barbados (101)	14	12	11	9	11	17	19	18	16	17	16	16
	70	70	70	75	75	75	75	75	75	75	75	70
Barcelona (19)	5	5	6	8	7	6	3	4	6	8	6	5
	50	45	50	50	50	45	30	45	40	50	55	45
Batavia (56)	20	19	16	12	9	8	6	4	6	9	13	16
	75	75	67	59	53	51	47	45	49	56	68	73
Bathurst (35)	*	*	0	0	1	5	14	21	16	6	1	*
	42	29	26	22	39	46	67	73	71	55	39	35
Belgrade (23)	12	13	15	14	15	16	12	10	12	12	12	13
	68	64	58	63	57	55	40	36	46	50	63	77
Berlin (16)	15	15	15	13	13	13	15	14	13	14	14	15
	73	72	66	60	56	56	61	58	55	65	73	77
Bermuda (88)	16	15	15	11	11	11	12	14	13	14	15	15
	65	65	62	58	59	56	53	51	52	57	60	63
Bombay (49)	*	*	*	*	1	14	21	19	13	3	1	*
	15	13	18	31	43	75	88	88	72	39	20	16
Bordeaux (18)	19	16	17	18	16	15	12	12	14	19	20	22
	74	63	66	66	70	66	59	57	50	60	76	75
Brest (5)	18	15	16	15	13	12	12	13	13	18	18	20
	74	71	64	62	55	60	58	55	59	65	70	75
Brisbane (70)	14	14	15	12	10	9	8	7	9	9	10	12
	64	64	55	45	43	42	38	34	37	45	53	58
Brussels (7)	15	15	15	16	16	17	16	16	16	17	18	16
	75	72	69	63	64	65	65	63	60	67	73	75
Bucharest (24)	9	8	10	10	13	13	10	7	8	8	10	9
	65	64	63	56	56	53	42	35	40	53	64	72
Buenos Aires (106)	7	6	7	8	7	7	8	9	8	9	9	8
	40	41	40	41	50	58	51	49	48	52	45	41
Bushire (47)	5	4	2	1	0	0	0	0	0	*	2	4
	45	40	41	33	22	2	8	10	6	10	26	47
Cairo (45)	3	2	2	1	*	0	0	0	0	*	1	2
	40	31	29	33	24	16	26	31	23	26	30	43
Calcutta (52)	1	2	2	3	7	13	18	18	13	6	1	*
	20	26	29	36	47	74	86	85	69	36	20	15

1st line: ave. number of days with rain; 2nd: ave. cloudiness

WEATHER AROUND THE WORLD

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Canary Is. (33)	8	5	6	3	1	1	1	1	1	5	8	8
	50	50	45	45	45	45	50	50	40	45	45	50
Capetown (38)	4	4	4	7	10	12	11	11	9	7	6	5
	31	30	36	46	52	44	53	52	52	48	42	34
Caracas (100)	6	2	3	4	9	14	15	15	13	12	13	10
	45	41	47	58	64	65	61	60	58	56	56	51
Chicago (81)	11	10	12	11	11	11	9	9	9	9	10	11
	63	62	61	56	53	47	43	45	49	50	61	65
Colombo (50)	10	4	11	16	21	20	18	14	17	22	19	12
	48	42	46	59	71	79	78	76	75	74	68	55
Constantinople (25)	10	8	9	7	7	5	3	4	6	7	11	12
	56	48	46	33	23	14	8	12	14	23	44	56
Copenhagen (10)	15	14	15	12	13	12	15	16	14	17	16	17
	78	77	70	62	58	58	64	64	60	72	78	83
Cristobal (97)	15	14	14	16	21	23	25	25	23	25	25	21
	47	49	47	56	72	78	77	76	73	74	74	58
Darwin (65)	19	19	16	8	2	0	0	0	2	6	11	16
	71	69	60	38	23	14	14	12	20	34	47	66
Dublin (1)	21	18	19	17	16	15	18	19	16	19	19	21
	64	64	59	58	60	62	68	63	58	60	62	63
Durban (39)	14	15	15	13	11	11	8	6	4	5	6	10
	60	55	52	39	31	24	25	35	51	62	64	63
Galveston (93)	10	9	8	7	6	7	9	9	9	7	8	10
	55	54	54	49	45	39	42	41	40	35	45	38
Georgetown (102)	20	17	19	17	23	25	24	17	8	7	13	22
	55	55	50	55	65	60	55	55	50	55	55	60
Gibraltar (32)	10	10	11	9	6	2	*	1	4	8	11	11
	45	49	49	40	38	27	22	26	40	44	49	43
Glasgow (2)	20	17	18	15	16	15	18	18	17	19	18	21
	80	80	70	70	70	70	80	70	70	80	80	80
Guam (63)	13	13	12	10	15	18	25	24	22	22	20	18
	71	71	70	66	65	68	78	81	80	77	77	70
Guayaquil (110)	16	14	12	8	5	2	2	*	*	1	*	5
	70	81	81	70	70	73	57	70	70	76	70	80

1st line: ave. number of days with rain; 2nd: ave. cloudiness

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Halifax (85)	17	14	15	15	13	14	13	12	12	13	14	15
	60	60	60	60	60	60	60	60	50	60	70	70
Hamburg (9)	18	17	19	16	16	15	19	19	15	19	18	19
	75	74	69	64	61	61	68	65	61	72	76	80
Havana (91)	8	6	5	5	10	13	12	14	15	15	10	8
	40	35	35	30	35	45	40	40	45	45	45	45
Hobart (68)	10	8	10	12	13	14	14	14	14	15	14	11
	60	60	59	61	60	61	58	59	61	63	63	62
Hong Kong (58)	6	8	11	12	16	21	19	17	14	8	6	5
	62	74	83	80	75	77	67	65	58	51	54	53
Honolulu (76)	14	10	13	12	11	11	13	13	13	13	14	15
	44	49	47	50	46	41	40	46	40	46	49	45
Jerusalem (46)	12	12	8	4	2	0	0	0	0	2	6	9
	46	46	30	33	13	7	5	4	12	15	26	37
Jidda (44)	3	0	0	*	0	0	0	0	0	0	4	2
	41	21	24	11	20	7	17	15	19	17	34	27
Juneau (77)	18	15	18	18	17	14	17	18	20	23	20	20
	77	76	78	77	73	70	76	76	74	86	78	79
Karachi (48)	1	1	1	*	*	1	2	2	1	0	*	1
	26	23	24	26	33	54	73	75	48	16	11	19
Kingston (98)	5	4	4	5	7	6	5	9	10	12	7	5
	42	43	46	50	56	61	52	58	63	62	59	46
Lagos (36)	2	3	7	10	16	20	16	10	14	16	7	2
	56	58	59	63	66	69	74	69	69	67	61	55
Leningrad (13)	17	15	13	11	12	12	13	15	14	15	17	18
	81	75	66	60	59	53	58	61	64	77	83	83
Lima (109)	1	1	1	2	5	14	19	24	25	12	8	4
	59	56	48	47	62	82	89	91	86	79	65	60
Lisbon (31)	13	12	14	12	9	5	2	2	6	11	13	14
	49	53	54	51	46	41	31	31	41	50	51	54
Loanda (37)	2	3	5	8	1	*	*	1	1	3	5	3
	58	59	64	70	53	47	51	55	54	59	64	64
London (4)	15	15	14	13	12	12	13	13	12	16	16	16
	74	71	68	64	63	64	65	63	60	65	71	73

1st line: ave. number of days with rain; 2nd: ave. cloudiness

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Los Angeles (80)	6	6	6	4	2	1	0	0	1	2	3	6
	44	47	46	45	46	37	30	27	30	31	33	37
Madras (51)	2	1	*	1	1	4	7	8	7	10	11	5
	34	25	22	40	38	57	69	66	62	52	55	57
Madrid (30)	9	10	10	10	10	6	3	3	7	9	10	10
	48	46	46	49	47	37	21	22	39	47	51	52
Malta (27)	13	10	8	5	3	1	*	1	3	7	11	14
	55	52	48	45	39	25	12	16	31	47	52	56
Manila (57)	5	3	3	4	10	16	21	22	21	17	12	9
	55	49	44	41	58	70	79	79	77	68	63	62
Marseilles (20)	7	9	10	8	9	6	5	4	6	14	11	10
	50	50	50	50	50	50	30	30	40	50	60	50
Mauritius (40)	19	18	21	18	15	16	20	20	15	14	12	16
	62	60	60	50	46	48	49	50	51	50	49	54
Mazatlan (94)	3	2	1	0	1	6	16	17	13	5	2	3
	31	28	27	27	25	34	54	52	48	21	23	23
Melbourne (67)	8	7	9	11	13	14	14	14	14	13	11	9
	51	50	55	58	65	67	63	63	61	60	59	55
Mexico City (95)	3	4	6	11	15	19	25	24	20	12	6	4
	30	28	31	42	51	67	72	72	74	55	43	37
Miami (90)	9	7	7	8	12	13	15	15	18	16	10	7
	53	48	48	50	58	65	61	59	63	61	56	53
Mombasa (42)	4	3	7	14	18	12	13	13	11	11	10	8
	44	44	40	53	57	46	50	49	42	43	46	44
Montreal (82)	12	11	13	12	12	12	11	11	10	12	16	14
	61	54	60	66	61	61	60	55	55	61	71	75
Moscow (14)	14	13	12	12	12	13	12	15	12	13	16	15
	73	71	62	56	51	58	50	54	51	74	87	79
Mozambique (41)	15	16	13	10	5	6	4	4	2	2	3	10
	82	89	63	48	40	46	58	44	42	51	40	62
Nassau (89)	9	7	6	6	11	13	16	16	17	14	9	8
	54	53	51	52	60	62	59	59	59	59	54	53
New York (86)	12	10	12	11	11	10	11	10	9	9	9	11
	61	58	58	59	57	57	57	56	52	50	59	61

1st line: ave. number of days with rain; 2nd: ave. cloudiness

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Norfolk (87)	11	11	12	10	11	11	12	12	8	8	8	10
	57	51	51	50	48	50	50	51	47	44	45	55
Numea (71)	10	10	13	13	16	13	13	11	7	7	7	7
	54	54	50	56	55	55	57	51	48	48	53	47
Oslo (11)	12	12	13	10	11	10	12	15	11	12	12	15
	71	68	65	61	58	56	58	63	61	69	72	74
Para (103)	27	26	28	27	24	22	19	16	16	15	12	19
	65	72	74	71	60	49	43	38	36	34	37	51
Paris (6)	14	14	14	13	14	12	12	12	11	15	15	15
	70	65	58	57	57	55	52	49	51	59	69	72
Pernambuco (104)	9	10	14	16	21	21	21	19	10	8	7	9
	43	47	47	48	54	56	55	53	42	38	40	44
Perth (66)	3	3	4	7	14	17	17	18	14	12	6	4
	29	31	35	45	55	63	57	56	53	53	41	33
Plymouth (3)	19	15	15	14	13	12	13	14	14	17	18	21
	72	69	61	59	58	64	62	59	55	66	67	74
Ponta Delgada (84)	14	14	11	10	10	8	7	7	11	14	14	14
(Azores)	65	65	65	63	60	60	54	51	54	57	63	65
Progreso (92)	4	3	3	2	4	7	8	8	9	8	5	4
	48	44	44	48	50	55	53	52	54	51	48	50
Punta Arenas (107)	11	9	12	12	13	8	9	8	8	7	9	10
	67	64	64	62	61	59	59	60	60	62	66	68
Rabaul (64)	19	16	18	17	13	12	10	11	10	9	14	16
	69	68	66	64	56	56	58	56	56	59	63	65
Rangoon (53)	*	*	1	2	14	23	25	24	20	10	3	1
	30	28	36	41	73	89	92	91	86	65	45	34
Rio de Janeiro (105)	13	11	12	10	10	7	6	7	11	12	12	14
	66	61	62	56	56	54	51	57	73	71	70	67
Rome (21)	11	10	11	12	9	6	2	3	6	12	12	12
	55	56	55	56	53	41	28	27	36	54	59	61
St. Johns (83)	15	13	14	13	13	12	12	11	12	15	16	15
	69	64	68	73	70	56	61	59	58	66	73	75
St. Vincent (34)	1	1	0	0	0	0	2	5	3	3	1	2
	50	40	40	30	30	40	50	50	40	40	40	50
San Francisco (79)	11	11	8	6	4	2	*	*	2	4	7	10
	54	53	46	37	37	32	37	42	34	36	45	49

1st line: ave. number of days with rain; 2nd: ave. cloudiness

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
San Juan (99)	21	15	16	14	16	17	19	20	18	17	20	22
	42	40	39	42	46	48	45	40	43	40	43	42
San Salvador (96)	1	1	2	4	12	19	20	20	17	16	5	2
	24	31	41	56	70	75	73	73	76	64	46	24
Shanghai (59)	10	10	13	13	12	14	11	11	12	10	8	7
	62	68	69	70	70	76	64	58	64	59	52	49
Singapore (55)	16	11	14	15	14	14	13	14	13	16	18	19
	51	44	44	47	48	51	49	51	53	53	56	53
Stockholm (12)	15	13	14	11	12	12	15	16	14	16	15	17
	76	73	66	60	56	54	59	60	59	72	74	81
Suva (74)	23	22	24	23	21	18	17	19	19	18	19	21
	57	56	56	55	59	56	56	63	62	61	63	59
Sydney (69)	14	14	15	14	15	13	12	11	12	12	12	13
	58	60	55	50	49	48	44	40	43	49	55	56
Tahiti (75)	16	16	17	10	10	8	5	6	6	9	13	14
	69	66	69	58	58	60	46	54	55	57	60	65
Tientsin (60)	3	3	3	4	6	9	13	11	7	6	4	3
	31	31	36	42	42	51	55	50	43	30	29	25
Tokyo (62)	7	8	13	14	14	16	15	13	17	14	10	7
	40	50	60	70	70	80	80	70	70	70	50	40
Tunis (28)	11	10	9	8	5	3	1	1	4	8	9	9
	69	66	55	56	50	36	43	42	57	53	55	62
Valparaiso (108)	1	*	1	3	6	8	7	6	4	3	1	1
	35	31	35	46	53	50	52	48	47	51	38	33
Vancouver (78)	21	16	16	14	13	11	7	7	11	17	22	21
	80	70	60	60	50	50	40	40	50	70	70	80
Venice (22)	6	7	9	11	9	10	6	7	8	9	8	7
	59	56	59	59	55	52	39	37	47	60	63	64
Vienna (17)	7	5	7	8	9	10	10	8	7	8	7	7
	74	68	58	57	56	56	49	43	45	56	71	76
Vladivostok (61)	3	3	5	7	10	13	13	13	10	6	4	3
	29	30	43	59	66	75	79	71	55	45	39	33
Warsaw (15)	15	15	14	14	13	13	15	13	11	12	14	15
	76	74	68	65	59	59	61	58	58	67	80	82
Wellington (72)	10	9	12	12	16	16	18	17	15	14	12	11
	50	50	60	60	60	60	60	60	60	60	50	50

1st line: ave. number of days with rain; 2nd: ave. cloudiness

TABLE IV

Days with Snow

Average number of days each month with snow; an asterisk indicates less than one. Data are given for all of the 110 cities shown by numbers in Figures 54 and 55 which have enough snow to be of interest, taken here as more than five days a year.

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Amsterdam (8)	4	3	3	1	0	0	0	0	0	*	1	3
Belgrade (23)	8	6	3	*	0	0	0	0	0	*	3	6
Berlin (16)	8	8	7	2	*	0	0	0	0	*	3	7
Brest (5)	1	2	2	*	0	0	0	0	0	0	*	1
Brussels (7)	6	6	6	2	0	0	0	0	0	0	2	5
Bucharest (24)	6	4	3	1	*	0	0	0	*	*	2	4
Chicago (81)	13	13	10	3	*	0	0	0	0	1	6	12
Constantinople (25)	4	5	3	0	0	0	0	0	0	0	0	1
Copenhagen (10)	9	10	9	3	1	0	0	0	0	*	3	7
Dublin (1)	4	4	5	1	*	0	0	0	0	*	1	2
Glasgow (2)	4	4	4	1	*	0	0	0	0	*	1	3
Halifax (85)	10	10	8	4	*	0	0	0	0	*	2	8
Hamburg (9)	8	8	8	3	*	0	0	0	0	1	3	6
Juneau (77)	17	16	18	10	1	0	0	0	*	3	8	16
Leningrad (13)	13	12	11	6	2	0	0	0	0	4	10	14
London (4)	3	3	3	1	*	0	0	0	0	0	1	2
Montreal (82)	16	14	12	5	*	0	0	0	0	2	8	15
Moscow (14)	14	13	10	6	*	0	0	0	*	5	13	14
New York (86)	9	9	6	2	*	0	0	0	0	*	2	7
Norfolk (87)	3	3	2	*	0	0	0	0	0	*	1	2
Oslo (11)	10	10	10	4	1	*	0	0	*	1	5	10
Paris (6)	4	3	3	1	0	0	0	0	0	0	1	2
Plymouth (3)	2	1	2	*	0	0	0	0	0	*	*	1
Punta Arenas (107)	0	0	0	2	4	5	7	5	3	2	2	0
St. Johns (83)	8	7	7	2	1	*	0	0	0	*	2	7
Stockholm (12)	12	12	11	5	2	*	0	0	*	1	6	11
Tientsin (60)	2	2	1	*	0	0	0	0	0	*	1	1
Tokyo (62)	4	5	3	*	0	0	0	0	0	0	*	2
Vancouver (78)	5	2	1	*	0	0	0	0	0	*	1	3
Vienna (17)	8	6	6	1	*	0	0	0	0	*	3	8
Vladivostok (61)	6	5	5	1	*	0	0	0	0	1	3	5
Warsaw (15)	13	9	9	3	0	0	0	0	*	1	7	10

APPENDIX B

SUPPLEMENTARY WEATHER RECORDS FOR 75 PLACES

(See key charts, Figs. 54 and 55)

TABLE V

TEMPERATURE AND RAINFALL

First line: Average temperatures by months and for the year.
Second line: Average amount of rain or snow in inches and tenths. Snow is given as the measurement when melted. Where the average monthly temperature is near 32 degrees, much of the amount given represents melted snow, and when the average is as low as 15 degrees it is practically all snow. At lower temperatures it is all melted snow. A foot of snow is roughly equal to about an inch of water.
Combinations of figures and letters (A1, C5, etc.) in parentheses after names of cities give their locations on the index charts, Figures 54 and 55.

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANN.
Abilene	44	46	56	64	72	79	82	82	75	65	53	46	64
(R1)	0.9	0.9	1.2	2.6	3.8	2.7	2.0	2.4	2.6	2.5	1.4	1.2	24.2
Alice Springs	83	82	77	68	60	54	53	58	65	73	79	82	70
(I5)	1.8	1.7	1.2	0.7	0.7	0.6	0.4	0.4	0.4	0.7	1.0	1.6	11.2
Amboina	81	81	81	79	79	78	77	78	78	79	80	81	79
(E5)	5.1	4.6	5.2	11.3	19.8	24.6	23.1	15.9	9.1	6.1	4.4	5.3	134.5
Angmagssa-	17	13	17	24	33	41	44	42	38	30	22	19	28
lik (K1)	3.5	1.7	2.2	2.4	2.8	2.1	2.1	2.5	4.0	6.3	3.4	2.7	35.7
Archangel	8	9	18	30	41	53	60	56	46	34	22	12	32
(B4)	0.9	0.7	0.8	0.7	1.2	1.8	2.4	2.4	2.2	1.6	1.2	0.9	16.8
Arica (E2)	71	72	70	67	64	62	61	61	62	64	66	69	66
	0	0	0	0	0	0	0	0	0	0	0	0	0
Ascension	79	81	82	81	80	79	78	77	77	77	77	78	79
Is. (H3)	0.2	0.6	0.9	1.5	1.2	0.5	0.5	0.8	0.4	0.3	0.2	0.2	7.3
Astrakhan	19	23	33	48	64	73	77	74	63	50	36	27	49
(I4)	0.5	0.3	0.4	0.5	0.6	0.7	0.5	0.5	0.5	0.4	0.4	0.5	5.9
Asuncion	80	80	78	72	67	63	64	66	70	72	76	80	72
(F2)	5.4	5.1	4.2	5.1	4.6	2.8	2.2	1.6	3.1	5.5	5.8	6.2	51.6

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANN.
Baghdad	49	54	61	70	81	90	94	94	88	78	63	53	73
(J4)	1.2	1.3	1.3	0.9	0.2	0	0	0	0	0.1	0.7	1.2	7.1
Barnaul	0	0	16	35	52	65	70	64	52	39	22	5	36
(N4)	1.5	1.1	1.0	1.3	1.7	1.3	2.0	2.0	1.6	1.7	2.0	1.6	18.8
Bismarck	9	9	24	43	54	64	70	68	58	45	28	16	40.7
(N1)	0.5	0.5	1.0	1.6	2.4	3.3	2.2	1.9	1.3	1.0	0.7	0.6	17.0
Blagovyesh-	–12	–3	15	36	53	65	72	67	54	36	12	–8	33
chensk (U4)	0.1	0.2	0.3	0.6	1.4	3.5	4.6	4.1	2.5	0.8	0.5	0.3	18.9
Bogota	58	58	59	59	59	58	57	57	57	58	58	58	58
(A2)	2.2	2.4	4.0	5.5	4.6	2.3	2.1	2.3	2.4	6.3	4.8	2.7	41.6
Bourke	84	83	78	68	58	54	51	56	63	70	76	82	68
(K5)	2.0	1.9	1.6	1.4	1.1	1.0	0.9	0.9	1.0	1.1	1.3	1.1	15.3
Broome	86	85	85	83	76	71	70	72	77	81	85	86	80
(G5)	5.0	6.4	3.8	1.5	0.4	1.1	0.4	0	0.1	0	0.9	3.5	23.1
Carnarvon	80	81	79	75	68	63	61	63	66	69	73	77	71
(H5)	0.3	0.6	0.5	0.6	1.3	2.8	1.9	0.6	0.3	0.1	0	0.1	9.1
Cloncurry	83	80	76	69	60	54	51	56	63	72	77	80	68
(J5)	5.1	4.9	2.6	1.0	0.4	0.3	0.5	0.1	0.5	0.5	1.0	3.0	19.9
Cordoba	74	72	68	62	56	50	50	54	59	63	68	72	62
(G2)	4.2	4.2	3.5	1.8	1.0	0.3	0.3	0.5	0.9	2.4	4.0	4.6	27.7
Cuyaba	81	81	81	80	78	75	76	78	82	82	82	81	80
(C2)	9.8	8.3	8.2	4.2	2.0	0.4	0.2	1.1	2.0	4.6	6.0	8.2	55.0
Denver	30	32	39	47	57	67	72	71	62	50	39	32	50
(O1)	0.4	0.5	1.0	2.1	2.4	1.3	1.8	1.4	1.0	1.0	0.6	0.7	14.3
Dutch Har-	32	32	33	35	40	46	51	51	47	41	35	32	40
bor (A1)	5.4	7.1	5.6	3.4	5.0	2.7	2.3	3.0	5.8	8.4	6.8	7.2	62.7
Edmonton	6	9	22	41	51	57	61	59	50	47	29	19	37
(F1)	0.8	0.7	0.8	0.8	1.7	3.1	3.5	2.2	1.4	0.7	0.6	0.7	17.0
Entebbe	71	71	71	70	70	69	69	69	69	70	70	70	70
(E3)	2.6	3.6	5.8	9.6	8.5	5.2	2.9	3.1	3.2	3.4	5.0	5.1	58.0
Eucla	71	71	69	66	61	56	54	56	59	63	66	69	64
(L5)	0.7	0.5	0.9	1.2	1.2	1.1	0.9	1.0	0.8	0.7	0.7	0.4	10.1
Falkland	50	49	47	42	41	36	36	37	39	41	45	47	42
Is. (I2)	2.8	2.3	2.2	2.4	3.0	2.4	2.2	2.0	1.3	1.5	2.1	2.8	27.0

1st line: ave. monthly temp.; 2nd: ave. inches rain or melted snow

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANN.
Fanning Is.	83	82	83	83	83	83	83	84	84	84	84	83	83
(B5)	8.0	8.3	7.4	9.0	10.4	10.1	6.5	4.3	3.0	3.5	3.4	7.1	81.0
Fort Good	–20	–20	–9	13	38	56	60	53	40	22	–5	–18	18
Hope (D1)	0.6	0.5	0.8	0.5	0.8	1.3	1.4	1.6	1.3	1.2	0.8	0.6	11.4
Hankow	40	42	48	61	71	78	83	83	75	65	53	43	62
(R4)	1.8	1.9	3.8	6.0	6.5	9.6	7.1	3.8	2.8	3.2	1.9	1.1	49.5
Hay River	–13	–9	2	19	38	49	60	56	46	34	11	–5	24
(E1)	0.8	0.9	0.8	0.7	1.0	1.6	1.3	2.0	1.8	0.6	0.9	0.9	13.3
Hebron	–5	–5	6	19	32	40	47	47	40	30	20	4	23
(I1)	0.9	0.7	0.9	1.1	1.6	2.1	2.7	2.7	3.3	1.6	1.1	0.6	19.3
Helena	20	22	32	44	52	60	68	67	56	44	32	25	44
(M1)	0.9	0.6	0.8	1.1	2.1	2.4	1.2	0.7	1.2	0.9	0.7	0.8	13.4
In Salah	55	59	68	76	86	94	99	97	92	80	68	58	78
(A3)					No rain of consequence								
Irkutsk	–5	–1	14	33	47	58	63	59	46	32	13	–2	30
(P4)	0.4	0.3	0.3	0.6	1.3	2.2	3.3	3.0	1.6	0.7	0.7	0.6	14.9
Jacobshavn	0	–2	3	14	32	40	46	44	36	25	16	9	22
(J1)	0.4	0.3	0.5	0.5	0.5	0.8	1.2	1.4	1.4	0.9	0.7	0.5	9.1
Kasan	8	11	21	38	55	63	68	63	52	38	24	14	38
(D4)	0.5	0.4	0.6	0.9	1.6	2.2	2.4	2.4	1.6	1.1	1.0	0.7	15.4
Khartoum	70	73	79	86	91	91	88	86	88	87	80	72	83
(B3)	0	0	0	0	0.1	0.3	1.8	2.6	0.7	0.2	0	0	5.7
Kiev	21	24	31	44	58	63	67	65	56	45	33	26	44
(G4)	1.1	0.8	1.5	1.7	1.7	2.4	3.0	2.4	1.7	1.7	1.5	1.5	21.1
La Paz	52	51	51	49	47	44	45	46	48	50	52	52	49
(D2)	4.4	4.3	3.0	1.5	0.6	0.3	0.5	0.7	1.1	1.6	1.9	3.7	23.6
Luktchun	13	27	46	66	75	85	90	85	74	56	33	18	56
(S4)					Very dry—No record								
Manaos	80	80	80	80	80	80	81	82	83	83	82	81	81
(B2)	8.7	8.1	8.6	8.5	6.8	4.0	1.9	1.3	1.8	4.5	5.6	8.1	67.9
Midway Is.	65	65	66	67	72	75	77	78	78	75	71	66	71
(A5)	4.4	3.6	3.4	4.3	3.2	2.2	4.1	3.7	5.1	2.6	2.6	2.9	42.5
Moose Fac-	–5	–2	10	28	42	55	61	59	52	40	22	5	31
tory (H1)	0.9	0.9	1.8	1.1	1.2	1.7	2.5	2.8	2.5	1.4	1.0	1.5	19.3

1st line: ave. monthly temp.; 2nd: ave. inches rain or melted snow

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANN.
Nashville	39	41	50	59	68	76	79	78	72	60	49	41	59
(S1)	4.7	4.2	5.1	4.4	3.8	4.2	4.1	3.5	3.5	2.4	3.5	3.9	47.3
New Ant-	79	80	79	78	79	78	76	76	77	77	78	78	78
werp (D3)	4.1	3.5	4.1	5.6	6.2	6.1	6.3	6.3	6.3	6.6	2.6	9.3	66.9
Nikolaevsk	–12	–4	9	27	38	53	62	61	53	36	14	–5	28
(V4)	0.2	0.2	0.3	0.7	0.8	2.2	3.8	3.4	2.0	2.8	1.1	0.6	18.1
Nome	1	6	8	17	34	45	50	50	41	29	14	6	25
(B1)	1.0	1.1	0.9	0.6	0.9	1.2	2.9	3.0	2.3	1.5	1.0	1.1	17.5
Novo Ma-	–10	–8	–4	6	25	40	50	49	38	23	7	–7	18
riinsk (Y4)	0.4	0.2	0.1	0.1	0.3	0.8	1.8	1.9	1.0	0.7	0.3	0.1	7.7
Novorossiisk	35	34	42	51	62	69	75	74	67	58	51	41	46
(H4)	2.1	2.6	1.7	1.6	1.6	1.3	2.9	2.1	2.3	2.1	3.0	3.7	26.9
Ocean Is.	82	83	83	83	83	83	82	83	84	84	83	83	83
(C5)	13.5	8.4	5.8	3.5	3.2	3.5	5.3	5.7	3.3	3.2	6.6	8.4	70.4
Okhotsk	–11	–4	10	23	34	45	55	56	48	28	8	–4	24
(W4)	0.1	0.1	0.1	0.2	0.5	1.1	0.6	1.9	2.1	0.6	0.2	0.2	7.7
Omsk	0	–1	14	33	51	66	68	61	51	38	21	3	2
(E4)	0.2	0.3	0.2	0.6	1.3	1.4	2.4	1.7	1.2	1.0	0.6	0.3	11.2
Peshawar	50	53	63	74	84	91	90	88	82	71	59	51	71
(M4)	1.7	1.5	2.0	1.5	0.7	0.5	2.2	3.3	1.2	0.3	0.4	0.6	15.9
Petropavlovsk	16	19	22	28	36	45	51	54	49	39	27	20	34
(X4)	2.9	2.2	3.3	2.0	1.8	1.4	3.7	3.7	2.7	2.5	2.0	2.5	30.7
Phoenix	50	54	60	67	75	84	90	88	82	70	59	52	69
(Q1)	1.0	0.8	0.6	0.4	0.1	0.1	1.4	1.0	0.7	0.5	0.8	0.7	8.1
Port Mores-	82	82	82	82	80	79	78	78	78	80	81	82	80
by (F5)	7.5	9.2	6.8	3.3	3.0	0.8	1.0	0.8	1.4	0.8	2.0	4.2	40.8
Port Nelson	–17	–13	–2	18	33	45	57	54	44	30	10	–9	20.7
(G1)	0.6	0.4	0.6	1.0	0.9	2.3	1.9	3.4	2.6	1.1	0.9	1.0	16.7
St. Louis	32	34	44	56	66	75	79	77	70	58	45	36	56
(P1)	2.3	2.6	3.5	3.8	4.5	4.6	3.6	3.5	3.2	2.8	2.9	2.5	39.8
Salisbury	70	69	68	66	61	57	56	60	66	71	71	70	65
(F3)	7.5	7.4	4.5	1.0	0.5	0	0	0.1	0.3	1.1	3.7	5.8	31.9
Sandakan	80	80	81	82	83	82	82	82	82	82	81	80	81
(D5)	18.4	9.6	8.0	4.1	5.9	7.3	6.5	8.1	9.4	10.0	14.7	17.7	119.7

1st line: ave. monthly temp.; 2nd: ave. inches rain or melted snow

STATIONS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANN.
Sarmiento	65	63	58	51	44	38	38	41	46	53	57	61	51
(H2)	0.3	0.4	0.4	0.3	0.5	1.0	0.6	0.5	0.4	0.5	0.2	0.3	5.3
Stykkisholm	30	29	30	34	41	48	51	50	46	39	33	30	39
(L1)	2.9	2.6	2.0	1.5	1.4	1.6	1.5	1.6	2.8	3.0	2.5	2.5	25.9
Surgut	–5	–8	10	25	38	58	64	57	47	32	12	–4	27
(C4)	0.9	0.6	1.1	1.1	1.7	2.2	3.7	3.5	2.3	1.8	1.5	1.0	21.4
Tamatave	79	80	78	77	73	70	69	69	71	74	76	78	75
(I3)	14.7	14.4	17.9	12.0	9.8	14.3	13.1	8.6	7.0	5.3	4.0	9.6	130.7
Tanana	–15	–4	6	24	44	57	59	53	40	22	–2	–11	23
(C1)	0.7	0.8	0.6	0.2	0.8	1.0	2.3	2.1	1.4	1.2	0.7	0.7	12.5
Tashkent	30	34	46	58	68	76	80	76	66	54	45	36	56
(L4)	1.8	1.4	2.6	2.6	1.1	0.5	0.1	0.1	0.2	1.1	1.4	1.7	14.6
Tehran	34	42	48	61	71	80	85	83	77	66	51	42	62
(K4)	1.7	1.1	2.0	1.4	0.6	0.1	0.2	0	0.1	0.3	0.9	1.2	9.5
Timbuctu	71	74	83	89	94	94	91	88	90	89	80	71	85
(C3)	0	0	0.1	0.1	0.2	1.1	3.4	2.3	1.5	0.1	0	0	8.8
Trondheim	27	27	30	38	46	53	57	56	50	41	32	28	40
(A4)	3.4	2.9	2.2	1.8	1.5	1.7	2.2	3.0	3.3	3.4	3.1	2.6	31.1
Turgai	2	2	19	42	61	74	77	73	59	42	29	10	41
(F4)	0.2	0.2	0.3	1.0	0.8	0.7	0.4	0.4	0.4	0.8	0.7	0.4	6.3
Turukhansk	–15	–14	–3	15	31	49	62	56	43	25	–1	–14	20
(O4)	0.6	0.3	0.6	0.6	1.2	1.6	2.0	3.2	2.4	1.5	1.0	0.7	15.7
Verkhoyansk	–58	–46	–24	8	35	55	60	51	35	5	–33	–50	3
(Z4)	0.1	0.1	0.1	0.2	0.3	0.9	1.0	1.0	0.5	0.4	0.3	0.1	5.0
Windhuk	74	72	70	66	60	56	56	59	66	70	72	74	66
(G3)	3.6	3.0	3.0	1.6	0.2	1.1	0	0.1	0	0.4	0.8	2.0	14.8
Yakutsk	–46	–31	–8	18	42	60	66	58	43	18	–18	–40	13
(T4)	0.9	0.2	0.4	0.6	1.1	2.1	1.7	2.6	1.2	1.4	0.6	0.9	13.7
Yunnanfu	49	51	57	62	67	69	69	69	65	59	54	50	60
(Q4)	0.7	0.5	1.1	1.0	3.7	6.3	10.0	8.9	6.2	2.9	1.3	0.4	43.0

1st line: ave. monthly temp.; 2nd: ave. inches rain or melted snow

APPENDIX C

Wind and Weather for Ocean Crossings

North Atlantic and North Pacific

I. NORTH ATLANTIC

January—Along the northern routes to Europe frequent storms, accompanied by strong winds and much rain, occasionally snow, are common in January. Many of these disturbances enter the ocean from North America, intensifying as they travel over the open sea; others arise over the ocean. They are often of wide extent, and a single disturbance may cover more than half the width of the North Atlantic between the British Isles and Newfoundland. Strong northerly to northwesterly winds are common in January along the coast of the United States from New England to the Carolinas, usually decreasing in strength southward from Cape Hatteras. Over the Gulf of Mexico, winds of gale force from a northerly quarter occur occasionally; this happens usually when cold weather extends southward over the interior of the United States.

Fog in January occurs more frequently in the area from Newfoundland to Cape Cod than in other parts of the North Atlantic, but it is to be expected there on only about three to five days a month. Fog occurs occasionally south of Cape Hatteras and in the Gulf of Mexico. On the whole, January is the month of least fog on the main trans-Atlantic routes.

On the northern routes, temperatures average 40° to 45° from New York to the Grand Banks, 45° to 50° in midocean and about 50° near the English Channel.

On the route to the Mediterranean, beyond the cold coastal waters of the United States, temperatures average 60° to 65°; in the Gulf of Mexico 65° to 75°; in Bahama waters 70° to 75°; and in the Caribbean Sea 75° to 80°.

February—The average weather conditions of February are about the same as January. As a rule the weather of February is a little stormier than January, although individual years may show the reverse condition. Temperatures do not differ much from the averages of January.

As in other winter months, the weather of the tropics is generally agreeable and free from storminess.

March—Since March is a transition month between winter and spring, weather conditions characteristic of both periods may be experienced on the North Atlantic. Wintry weather continues to predominate, but gales usually become less frequent toward the end of the month. Sometimes, however, March is the stormiest month of the cold season.

In the vicinity of the Grand Banks, fog becomes more frequent than in preceding months and may be expected on about two days out of five. Coastal fogs from Hatteras to Nova Scotia are about half as frequent as in the Grand Banks area.

Temperatures over the ocean have not begun to rise appreciably; and the January averages may be used for March.

April—The weather becomes more settled over middle and North Atlantic waters in April. Stormy weather continues, but conditions are less severe and the intervals of favorable weather are of longer duration. In southern waters, the trades are less frequently interrupted in coastal areas by offshore winds and are steady over the whole region between 5° and 25° north latitude.

Fogs show a definite increase from the Grand Banks area to Cape Cod and may be expected on twelve days in April near the Grand Banks and two to six days southward of Cape Cod.

On the northern routes, temperatures average about 50° from New York to the Grand Banks, 50° to 55° in midocean and about 53° near the English Channel. On the route to the Mediterranean, beyond the cool coastal waters, temperatures average 60° to 65°; in the Gulf of Mexico 72° to 76°; in Bahama waters 74° to 76°; and in the Caribbean Sea 78° to 80°.

May—There is considerable moderation of the weather over the northern routes in May; it is generally a pleasant month. Gales occur, however, north of 40° north latitude with considerable frequency, especially in the first part of the month. South of 40° north latitude, gales are infrequent.

Fog continues to increase in frequency in the neighborhood of the Grand Banks and southwestward to the Virginia Capes. Between Newfoundland and Nova Scotia fog may be expected on half the days of the month.

Temperatures continue to rise in May, especially over the western part of the northern routes. Averages are about 60° from New York to the Grand Banks, 55° to 60° in midocean and about 55° near the English Channel.

On the Mediterranean route, beyond cool coastal waters of the United States, averages are 66° to 70°; in the Gulf of Mexico 76° to 80°; in Bahama waters 78° to 79°; and in the Caribbean Sea 80° to 81°.

June—A small amount of storminess usually occurs in June along the northern routes, but the month is generally pleasant over the whole North Atlantic. In the stormiest part of the North Atlantic gales are experienced on only one or two days of the month.

June is the beginning of the hurricane season in southern waters but they are rather rare and usually not of marked severity. When they do occur, they are confined almost entirely to the western Caribbean Sea and the Gulf of Mexico.

Fog increases to its maximum frequency of the year in the neighborhood of the Grand Banks, averaging about twenty days a month in June. There is considerable fog, as a rule, as far south as Long Island.

Temperatures average 62° to 68° from New York to the Grand Banks, and about 60° over the middle and eastern sections of the northern routes to Europe. On the Mediterranean route the average is 70° to 75°; in the Gulf of Mexico, Bahama waters and the Caribbean Sea 80° to 82°.

July—This is a very favorable month. Gales are uncommon and seldom of great force. An occasional tropical cyclone occurs in southern waters but they usually move westward or northwestward to the Gulf of Mexico or southern United States and scarcely ever reach northern waters with dangerous intensity. However, the average for the whole region for July is only about one in

two years, hence the hazard in southern waters is extremely small for any one voyage.

Fog continues at maximum frequency in the neighborhood of the Grand Banks and is still quite common from Newfoundland southwestward to the Virginia Capes. It is rather frequent also over the middle and eastern parts of the northern routes.

Temperatures continue to rise. On the northern routes the temperature averages generally in the sixties; on the Mediterranean route in the seventies and in southern waters in the low eighties.

August—Weather continues favorable on the northern routes. Storms are rare and only those originating in the tropics are of dangerous force. As an average only about one or two tropical storms occur in August. They usually move to the Gulf of Mexico or southern United States in the first half of the month but a large proportion have visited northern waters in the latter half of the month. The hazard on a single voyage is very small.

Fog diminishes in frequency and general extent from July to August. On the western third of the northern route to Europe fog may be expected on seven to twelve days during the month.

Temperatures average 70° to 75° from New York to the Grand Banks, 60° to 65° in midocean and about 63° near the English Channel. On the Mediterranean route the average is 75° to 80°; in the Gulf of Mexico, Bahama waters and the Caribbean Sea 82° to 83°.

September—With the approach of autumn, quiet conditions that prevail in higher latitudes in summer begin to be replaced by increased atmospheric activity. Gales become more frequent, especially toward the end of the month. On the whole, however, the weather remains decidedly favorable.

In southern waters, the tropical cyclone reaches its peak of frequency which is only about two a year in September. However, in some years there has been none in September, in others as many as seven have been in progress during September. About half of the September hurricanes move to higher latitudes; they occasionally affect the northern routes to Europe. The likelihood of encountering a hurricane on any single voyage is, however, very small.

Fog continues to decrease in September. The foggy regions are quite limited in extent to the eastward of New England and Newfoundland.

Temperatures begin to fall slightly toward the end of September. On the northern route, New York to the Grand Banks, the average is 65° to 70°, in midocean about 60°, and near the English Channel about 62°. Going toward the Mediterranean, beyond coastal waters of the United States, the average is 75° to 80°, in the Gulf of Mexico, Bahama waters and the Caribbean Sea the average is about 82°.

October—There is a decided change to cooler and more stormy weather during October. The chance of stormy weather is about twice that in September on the northern routes. In the stormiest part of the ocean, however, the expectation of gales is not more than one day in six. Pleasant, bracing weather is frequently experienced with temperatures only slightly lower than in September.

Fogginess diminishes; the likelihood is about one day in three in the foggiest sections of the northwestern North Atlantic.

Tropical storms average about two a year in October. More than half of them pass northward or northeastward to the middle and northern routes.

On the northern routes to Europe, temperatures average 58° to 62° from New York to the Grand Banks, 55° to 60° in midocean and about 58° near the English Channel. On the route to the Mediterranean, beyond coastal waters of the United States, the average is 72° to 76°, in the Gulf of Mexico 76° to 80°, in Bahama waters 79° to 81° and in the Caribbean Sea 81° to 83°.

November—There is a further increase in storminess in the northern half of the ocean. Occasionally November is about as stormy as midwinter but as a rule the month is not severe. Along the American coast, gales occur on about one day in ten. Tropical cyclones are rather rare, there being an average of one in two years in November.

Fog continues to diminish in frequency and extent.

Temperatures are lower, especially on the western third of trans-Atlantic routes. From New York to the Grand Banks the average is 50° to 60°, in midocean 50° to 55°, and near the English Channel about 55°. On the Mediterranean route, beyond the coastal waters of the United States, the average is 68° to 74°, in the Gulf of Mexico 72° to 76°, in Bahama waters 75° to 78°, and in the Caribbean Sea 80° to 82°.

December—This is usually one of the stormiest months of the cold season on northern routes. Conditions in general are quite like January and February, except that the temperature is not quite so low. Tropical storms are practically nonexistent; there is an average of about one in twenty-five years in December.

Fog occasionally extends southward beyond Cape Hatteras and occurs sometimes in northern waters of the Gulf of Mexico, but on the whole it is about as infrequent as in January.

It is colder in the northwestern part of the ocean; from New York to the Grand Banks the average is 45° to 50°; in midocean the average is about the same; near the English Channel it is about 52°. On the middle and eastern Mediterranean routes the average temperature is 65° to 70°, in the Gulf of Mexico 70° to 75°, in Bahama waters 74° to 76° and in the Caribbean 79° to 81°.

II. NORTH PACIFIC

January—Along the northern routes from Pacific ports of the United States toward Asia, much stormy weather, with rain and occasionally snow, occurs in January. Gales, especially on the middle and western sections of the northern routes, are frequently strong and sometimes increase to the force of a hurricane. There is usually quieter weather on the middle routes. In Asiatic waters the northeast monsoon prevails, sometimes with overcast, rainy weather. Tropical cyclones occur in this region at the rate of about one in two years. On the route from west coast ports to the Panama Canal there are occasional strong winds on the Gulf of Tehuantepec.

Fog is seldom experienced except in coastal waters of America and Asia. January is a favorable month in the Tropics.

On the northern routes, temperatures range between 52° and 36° in Asiatic waters, 35° to 40° in midocean, and 42° to 45° near the American coast. The middle route is a little warmer, averaging 46° to 53° in midocean.

February—Weather conditions in February are quite similar to those of December and January. Typhoons are rare in February, there being an average of about one in four or five years. Temperatures are a degree or two colder over the northern and middle routes than in January.

March—March is frequently as stormy as the winter months, but as a rule the weather is better, especially toward the end of the month. Typhoons in Asiatic waters are rare, averaging about one in three years in March. There is no appreciable increase in fog over the winter months.

Temperatures on the northern and middle routes are practically the same as in January.

April—As an average, conditions in April show a decided improvement in higher latitudes of the Pacific. Severe storms occur occasionally, however, and fog shows a slight increase over winter months, especially on the western half of the ocean. Typhoons are rare, averaging about one in three years.

In western sections near the coast of Asia, temperatures range from 58° to 42°; in midocean 37° to 42°; on the eastern parts of the routes, approaching United States ports, the average is 45° to 47°. The middle routes average 46° to 56° in midocean.

May—May is usually a pleasant month for travel on the North Pacific. Along the northern routes some storminess may be expected, though it diminishes as the month advances. The majority of vessels making North Pacific crossings in May do not experience winds of gale force. This is especially true of the middle routes. Occasional storms, some of tropical origin, move northward or northeastward in waters east of Japan. Fog is experienced most frequently on the northern routes from the Aleutian Islands toward Japan where it is found on six to eight days in a month. Typhoons are on the increase but do not average quite one a year in May.

Outward from Asia the temperature averages 63° to 45°, in midocean on the northern routes 40° to 45° and in the eastern part of the ocean, approaching the coast of the United States, 45° to 50°. The middle routes average 48° to 58° in midocean.

June—This is generally the most pleasant month of the year for trans-Pacific travel. The northern routes are comparatively free of stormy weather. Fog is the principal source of discomfort; it occurs rather frequently along the west coast of the United States and over the strip of ocean between the Aleutians and Asia. Storms rarely occur in June on the middle routes. Typhoons in Asiatic waters are on the increase, averaging one a year in June.

Temperatures are higher in coastal waters near Asia, ranging from 68° to 47° as the ship steams eastward; the average is 42° to 46° in midocean of northern routes, 50° to 60° in midocean on the middle routes, and 50° to 55° as the ship approaches United States ports.

July—Except for an increase in fogginess and in the frequency of typhoons in Asiatic waters, July is more favorable for travel than June. Storminess is at a minimum in northern waters. July is the foggiest month of the year in northern waters; it is especially prevalent on the western half of the northern routes. There is much less fog in middle latitudes and it is practically nonexistent south of 30° north latitude. Typhoons, originating mostly in waters east of the Philippines, average about three a year in July. Some move west-

ward and cross the Philippines into the China Sea while others move northwestward toward China or Japan. On any single voyage, the hazard of a typhoon is very small. There is an occasional tropical cyclone or hurricane off the west coast of Mexico; they are not as frequent as one a year, however, in July.

Temperatures continue to rise over the ocean in July. Outward from Asia on the northern routes, temperatures range from 74° to 55°; in midocean 47° to 52°; in eastern parts of the northern routes the average is 54° to 58°. The middle routes in midocean average 58° to 68°.

August—Temperatures continue to rise; August is the warmest month of the year over the North Pacific. Weather is generally favorable over northern routes. There is little storminess, the principal exception being an occasional tropical storm in Asiatic waters or off the Mexican coast. An average of about four typhoons occur in the Far East in August and about one hurricane in waters off the Pacific coast of Mexico and Central America.

The frequency of fog diminishes, especially toward the end of the month.

Outward from Asia, temperatures range from 78° to 60°; in midocean on the northern routes the average is 50° to 55°; on the middle routes 62° to 72°; in eastern sections, approaching the American coast 57° to 60°.

September—Early storms of the winter type begin to make their appearance on the northern routes with greater frequency. Some rough weather may be expected, especially in western parts of the ocean. As an average there are three or four typhoons in September and two hurricanes off the west coast of Mexico.

Fog may be expected along the northern routes and along the American coast from Vancouver to San Francisco and sometimes to the southward along the California coast.

Temperatures are only slightly lower than in August; near Asia the range is from 75° to 60° on the northern routes; 48° to 53° in midocean in the north and 61° to 70° in middle latitudes; 55° to 58° in waters near the United States.

October—The frequency of tropical storms diminishes but storms of the winter type become more prevalent on the northern routes. Occasional storms north of 30° north latitude are attended by winds of hurricane force. In tropical waters of the Far East there are about three typhoons in October, as an average. Some of them recurve and pass to the northward or northeastward in waters east of Japan. Mexican west coast storms are less frequent than in September.

Fog decreases materially along the northern routes and in coastal waters subject to it.

Temperatures are lower. Going eastward from Asia, the range is from 68° to 55°; in midocean on northern routes the average is 45° to 50°; on middle routes in midocean 54° to 64°; on approaching the American coast the average is 53° to 56°.

November—November is usually a stormy month in the northern part of the Pacific Ocean. Winter conditions have not, as an average, fully set in, but an occasional November is the stormiest month of the winter season. The frequency of typhoons in the Far East lessens rapidly and tropical storms are rare off the Mexican coast.

Fog is infrequent; it is more likely to be found off the west coast of the United States than elsewhere.

Temperatures are about 5° lower, as an average, over all the northern and middle routes, than in October.

December—With winter well established on the northern routes, December averages about as stormy as January and February. Storms of wide extent, sometimes accompanied by winds of hurricane force, rain, or snow, occur on the northern routes and strong winds are felt on the middle routes and occasionally as far south as 20° north latitude. The weather is especially stormy in the northwestern part of the ocean. Occurring on an average of only one a month, the typhoons of the Far East are not an appreciable hazard. Violent northerly winds are sometimes felt in the Gulf of Tehuantepec when cold weather prevails over the Gulf of Mexico. An occasional storm is encountered between the Hawaiian Islands and California.

Fog is infrequent along the northern routes; some fog may be expected along the American coast.

Temperatures are decidedly lower in northern waters eastward from Asia, ranging from 55° to 40°; in midocean on the northern routes the average is 38° to 42° and on the middle routes 47° to 55°; the eastern third of the northern routes, approaching the American coast, has an average of 43° to 48°.

SUBJECT INDEX

(Names in italics refer to ships. Key charts and references to weather tables will be found on pages 146 to 149. See also Geographical Index and Appendix.)

GEOGRAPHICAL INDEX

(This index contains all place names mentioned in the text and tables. The letter A after a name indicates that weather records for that place are given in Appendix A; B indicates weather records in Appendix B; C refers to information in Appendix C; K indicates that the key charts on pages 146 and 148 contain references to records for places in the area named. See also Subject Index.)